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METAL TREATING

SIXTH ANNIVERSARY ISSUE

Martempering "Four Wheel Drive" heavy duty transmission gears. (See page 2)

THE *Only* MAGAZINE DEVOTED EXCLUSIVELY TO THE HEAT TREATING INDUSTRY

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EDITORIAL

The Metallurgist—The Man of the Future

Editor's Note: This being our Sixth Anniversary, we asked the man who, more than any other, is responsible for the existence of METAL TREATING, to give us some thoughts about the present-day status of heat treating and metallurgy. They are presented below as they so adequately express the ever-increasing importance of heat treating and metallurgy since the dawn of civilization. C. E. H.

Possibly the blacksmith, whose descendants have acquired the more dignified title of "metallurgist" and created the very complex profession of "metallurgy", is the father of all engineering. He was, throughout history, and is today, a practical man who got things done. He made and heat treated the tools, utensils and weapons required in each phase of civilization. He traveled with the armies, setting up his portable forge, making his charcoal and often his metal from local sources. He was undoubtedly the first miner and the first mechanical engineer. Then civil engineering was born but still the iron-master had to forge or cast metal elements for bridges, water pipe, plow shares and flour mills powered by water or air. The first to dabble in chemistry was undoubtedly a blacksmith gone high-brow, such as Nostradamus, and who will say that the great Leonardo da Vinci, in his lesser known but very significant activities in engineering, was not proud of his smithing capacity?

The other day a young metallurgist came in to discuss a problem from his home base, Oak Ridge. I commented that there must be a great many physicists in atomic energy. He said, "No, mostly metallurgists. The physicists think up the ideas, but we have to make them work." Supersonic planes and their jet engines are limited in performance today solely by the ability of modern alloys to stand the terrific stresses and the high temperatures to which they are exposed. Jatos, guided missiles and even the man-made satellites, are basically dependent upon the most advanced metallurgy. The famed *Nautilus*, atomic submarine, is an intricate collection of difficult metallurgical problems solved. Every accomplishment in speed, endurance and lightness, is based upon metallurgical advances. These are just some of our modern frontiers.

More common, though attracting less attention, is the whole vast empire of industry on which our daily lives depend. Manufacture, transportation, communication, food production or whatever you care to name depends for existence on good metallurgy, and, in increasing numbers, upon good heat treating.

Reports from behind the Iron Curtain indicate that they are training twice as many technical men each year as we are. They recognize their importance in military, industrial and economic progress. Metallurgists are placed at the top of the list, and some even have private chauffeurs!

Every normal person wants to feel that he is in some way important to his fellow men. The student seeking an essential place in our nation today, if he has the qualifications, cannot do better than to learn this wonderful, basic and almost magical modern science dealing with the behavior of metals and alloys. In other words—become a metallurgist—the man of the future.

Horace C. Knerr
Chairman, Publication Committee.

CONTENTS

THE RELATIVE IMPORTANCE OF MATERIAL SELECTION TO THE METAL TREATER

By **JAMES SORENSON,** *Chief Metallurgist,*
Four Wheel Drive Auto Company,
Clintonville, Wisconsin

ONE of the frequent problems confronting both the industrial and commercial heat treater is that of having such parts as are submitted to him for heat treatment made from a material which will respond successfully and economically to the prescribed heat treating procedure.

Usually when the commercial heat treater becomes involved, the part in question has already been made and is supposed to be ready for heat treatment. Often we find that little or no thought has been given to the question of how the material from which the part is made behaves in the various heat treating operations, as well as to its machinability rating. Both of these factors have a major influence on the service performance and the overall cost of the part, and, of course, should be of deep concern to both the producer of the part in question, and the heat treater.

It thus becomes apparent that both the producer of the part in question and the heat treater have a mutual interest in the selection of the proper steel in parts to be heat treated. The cooperation of both parties on this matter of material selection should result in better service performance, and in most instances, lower overall cost for the producer of the parts in question.

As one of the major operations performed in both commercial heat treating and "captive" plants is the heat treating of carburized and hardened automotive gears, we are taking this opportunity to illustrate a procedure of selecting the proper alloy steel for carburized and hardened automotive gears, which has been used successfully in our plant, with the hope that this procedure may be of some assistance to the heat treating industry.

In addition, this procedure of material selection is applied to alloy steel, carburized and hardened automotive gears; this same procedure could also be modified to fit other heat treated parts as well.

As it is the heat treaters' responsibility to treat his company's or his customer's gears so that they will render satisfactory performance at a minimum cost, his knowledge of the proper procedures to be applied to many types of steel and various intricate designs and shapes should be made available to the designer and producer of the gears before the manufacture is started.

For example, if the heat treater was given the opportunity of reviewing the drawing or blueprint of the particular part or gear in question before it is placed in production, it would enable him to make such recommendations in the selection of material as would assure successful heat treating operations.

Thus, the heat treater, by making his knowledge available, will be able to assist in the specification of a material which will react satisfactorily to the various heat treating operations to which it may be subjected. By this means such difficulties as excessive distortion or warpage, improper core or case hardness, too shallow or excessive case depth may be avoided. In many instances the heat treater is blamed for these difficulties although he may have had no voice in the selection or control of the material used.

Alloy Gear Steels

Since some alloy steels may be less subject to distortion or warpage than others, depending upon the size and shape of the gear, the depth of carburized case required, core hardness, grain size, and the type of equipment available for heat treating, the importance of the heat treater's suggestions in the selection of the most suitable material becomes readily apparent both to the designer and the producer. It is hoped that the following procedure may be of some assistance to the designer, producer, and heat treater in selecting that particular alloy steel best suited to produce gears and other products that will render maximum performance in service at minimum cost.

Alloy gear steels may be defined as those steels which owe their special properties to the presence of one or more special elements such as chromium, nickel, molybdenum, vanadium, and manganese for the definite purpose of producing specific physical properties in response to heat treatment.

These alloy gear steels should conform to the following physical characteristics:

1. The steel must forge successfully.
2. The steel must respond to the annealing cycle so that the proper machinability micro-structure is readily obtained.
3. The steel must react properly to heat treatment.
4. The results of heat treating the steel must be such that minimum distortion can be expected.
5. The steel must be uniform from one heat lot to the next.

The selection of an alloy gear steel, to insure successful performance and also keep the cost of manu-

facturing at a minimum, is seldom a simple matter, but is frequently a compromise between opposing factors. However, it should be based on coordination of the material with engineering design.

This requires a knowledge of the service required of the gear in question and likewise of the physical characteristics of the different alloy gear steels commercially available. And, also it should include consideration of such factors as machinability, heat treatment, and the cost of the alloy gear steel itself.

Material Selection Factors

With these objectives in mind, we have used the following procedure in selecting alloy gear steel carburized and hardened automotive gears. In selecting a gear steel, we are concerned with four important material selection factors, namely:

Selection Factor #1: This involves the satisfactory performance or load carrying capacity of the gear in question and is relative to the applied unit stress in pounds per inch of tooth face and the pitch line velocity of the gear in question.

Selection Factor #2: The rate of machinability of the steel directly affects the overall cost of producing the gear, as the cost of the various machining operations include the factory burden, while the cost of the material or steel usually does not include this item. Hence, this machinability factor becomes very important from an overall cost point of view.

Selection Factor #3: How does the material perform in the various required heat treating operations? Is it subject to excessive distortion, causing the gears to run out and become noisy in operation and subject to local excessively high unit stresses, which would render the gear unfit for use? Does the gear steel scale excessivley in heating? Is the gear steel affected by slight temperature variations?

Selection Factor #4: The cost of the gear steel per pound and the availability of the same. But, as the gear steel usually does not carry the cost of the burden or overhead, the influence of the price per pound on the total overall cost of the gear is usually not as great as factors #2 and #3 depending upon the amount of machining and heat treating labor necessary to produce the gear in question.

Classification of Alloy Steels

In this procedure of selecting alloy steels for automotive gears, the various alloy gear steels are classified into three groups, based upon their respective physical properties, which are as follows:

Group #1: Krupp steels, of the following chemical composition: Carbon, .08 - .16%; Manganese, .30 - .60%; Phos., .020 Max.; Sul., .025 Max.; Chrome, 1.20 - 1.75%; Nickel, 3.85 - 4.30%, are among the strongest and toughest alloy gear steels obtainable and are used where stresses are very high and where weight must be kept at a minimum and redesign is not practical.

Group #2: Specs.-4820, 43BV14, 9310, 3310, which are a little lower in cost per pound of alloy gear steel than *Group #1* and while this group is not quite equal in physical properties to *Group #1* alloy gear steels, they are still regarded as intermediate high strength alloy gear steels.

Group #3: Specs.-4620, 3120, 2320, 6120, 4120, 8620, 8720, which are the more commonly used alloy gear steels and are regarded as medium strength alloy gear steels.

These three groups of alloy gear steels are plotted on a chart according to the Comparative Physical Characteristics of Alloy Steel Carburized and Hardened Gears, as shown in Fig. 1.

While this chart has been prepared for automotive gears used in "Four Wheel Drive" trucks designed for heavy duty snow removal at sub-zero temperatures, the slopes for the various groups of alloy steels are relative and these slopes could easily be adjusted to meet other special service requirements for alloy steel carburized and hardened gears.

In selecting a gear steel for a satisfactory performance at a minimum cost, careful consideration must be given to each of the *Four Selection Factors* given above.

And, as each gear must have sufficient strength to safely perform its proper function, our first consideration is *Selection Factor #1* and in this instance, the designer of the gear will supply the loads in pounds per inch of tooth face and the pitch line velocity of the gear in question as both of these factors are directly relative to the strength and the service life of the gear. When the load in pounds per inch of tooth face and the pitch line velocity have been definitely established, we can by referring to the chart shown in Fig. 1 select the particular group of alloy steels which will perform satisfactorily in regard to wear and fatigue and which are also directly related to the endurance life of the gear in question.

Use of the Chart

In this comparison chart, (Fig. 1), the various gear steels are grouped in three groups as shown by the three variable curves, and while representative of a specific type of heavy duty service, these curves could be plotted to conform to other types of service as well.

Group #1 curve refers to the Krupp steels and are among the strongest alloy gear steels obtainable.

Group #2 curve refers to the intermediate high strength alloy gear steels.

Group #3 curve refers to the lower alloy medium strength alloy gear steels.

In using the chart, we merely plot the tooth load in pounds per inch of face with the pitch line velocity and select the curve which appears most suitable for the gear under consideration. Hence, when the proper curve has been determined, we can readily select the group of alloy gear steels which will perform satis-

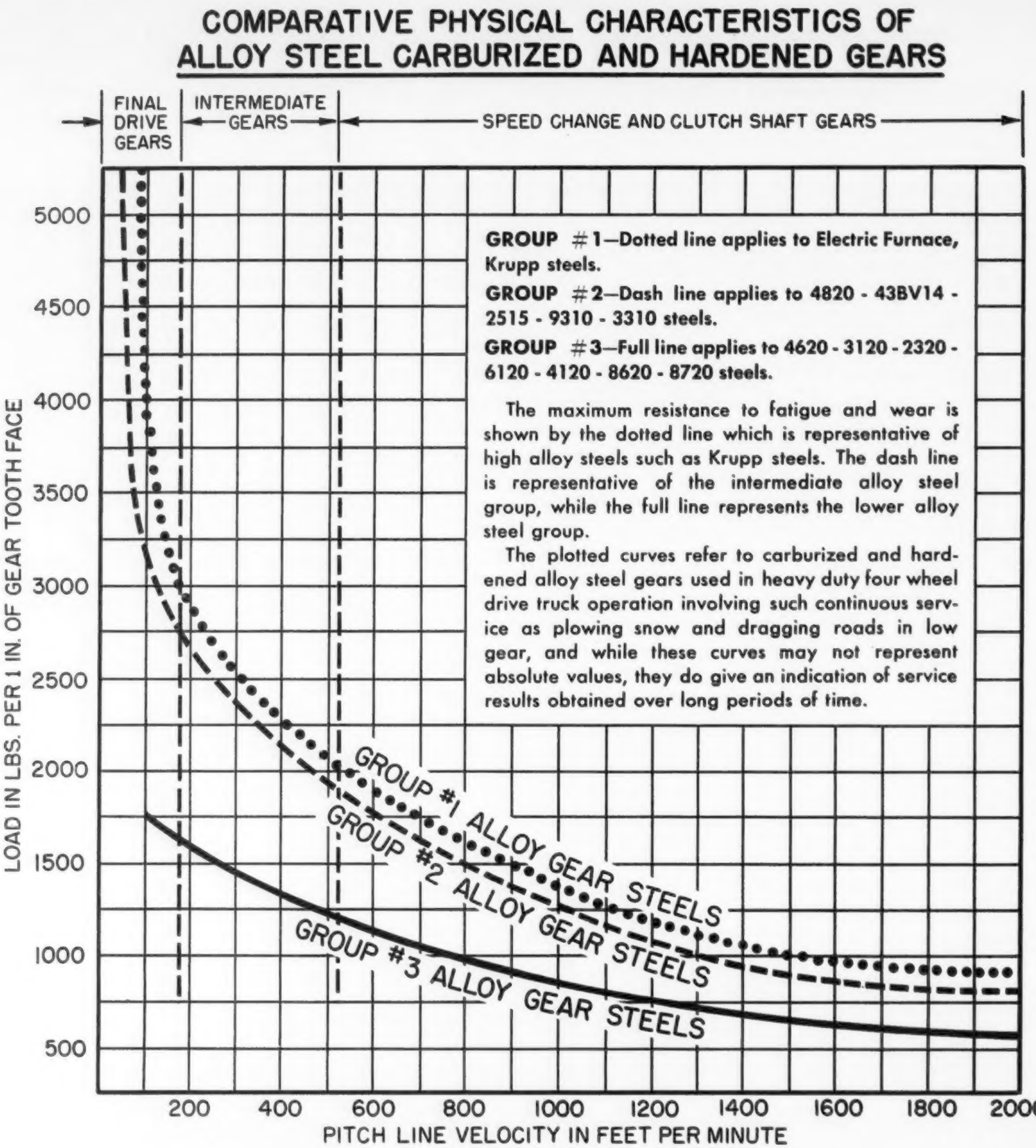

Figure 1.

factorily in service under the applied unit stress and pitch line velocity.

As a means of illustration, let us suppose our tooth load per inch of face is 1250 pounds and the pitch line velocity is 500 feet per minute. Referring to our comparison curves, we find that curve #3 would meet the requirements. Hence, any of the alloy gear steels known as Group #3, which include the following specs, namely: 4620, 3120, 2320, 6120, 4120, 8620, 8720 alloy gear steels would be satisfactory for *Selection Factor #1*.

Having determined *Selection Factor #1*, we can now proceed to determine *Selection Factor #2*, and as this involves the machinability of the material, we will refer to a machinability table, from which we may find that 4620 has the highest machinability percentage rating of the Group #3 steels. Hence, 4620 steel would be desirable for *Factor #2*.

We will now proceed to *Selection Factor #3* which involves the heat treatment and is dependent upon the type of heat treating equipment available, the size, shape and dimensional tolerances of the gear to be heat treated, as well as the heat treating procedure. Any or all of these factors may influence the selection of the specific alloy gear steel to be selected for the gear in question. If we assume that the gear in ques-

tion is a transfer or transmission gear where distortion in heat treatment is of serious importance to insure a minimum of noise in operation and good tooth contact with minimum run out, then suppose (based upon our past experience with our present heat treating equipment) we found that 4620 would be the most desirable alloy steel from the Group #3 alloy gear steels, as it would be subject to less distortion in heat treating than any of the other steels in Group #3.

Finally, we come to *Selection Factor #4*, and as we are assuming that in this case we are considering a transmission or transfer gear, *Selection Factors #2 and #3* would become very important as there would likely be considerable machining and heat treating labor involved which would also include the factory burden. The alloy differential cost, at the present time, on the Group #3 steels are as follows:

Spec.	*Alloy Extra Cost*
4620	$3.10 per 100 pounds
3120	$2.55 per 100 pounds
2320	$4.50 per 100 pounds
6120	$2.05 per 100 pounds
4120	$1.30 per 100 pounds
8620	$2.00 per 100 pounds
8720	$2.10 per 100 pounds

With the exception of the 2320 alloy gear steel, the balance of the Group #3 alloy gear steels are not too widely spread. As the cost of material usually does not include the factory burden, the difference in cost per pound of the 4620 steel, as compared with the other lower priced alloy gear steels in Group #3, may be more than compensated for by the advantages gained in *Selection Factors #2 and #3*; namely, heat treating and machinability.

From the foregoing, it becomes apparent that in order to specify a definite alloy steel for an automotive gear which will perform satisfactorily in service and which can be manufactured at a minimum cost, we must first be familiar with the service requirement of the gear, after which the various alloy gear steels are evaluated according to their physical properties, machinability, adaptability to heat treatment and price per pound of the alloy gear steel itself.

Fig. 2—Some carburized and hardened alloy steel automotive transmission gears made from fine grain 4820 steel.

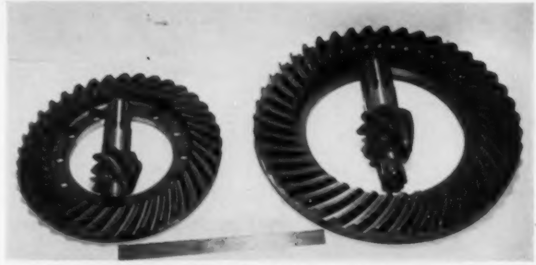

Fig. 3—Two sets of carburized and hardened alloy steel axle differential, spiral bevel, ring gears and pinions made from fine grain chrome nickel alloy Krupp steel.

Fig. 2 is a photograph of a few carburized and hardened alloy steel automotive transmission gears. These gears are made from fine grain 4820 steel and are crown shaved after which they are carburized to produce an effective case depth of .045" to .060", which is followed by martempering to a Rc hardness of 62 - 64 for the case, and 34 - 38 Rc hardness for the core. After grinding, these gears are held to a maximum runout tolerance on the pitch line of .002" and being helical gears, the helix angle lead tolerance is held to .0001" per inch of tooth length, which is a typical procedure in the production of heavy duty auto truck transmission gears.

Fig. 3 shows two typical sets of alloy steel carburized and hardened axle differential spiral bevel ring gears and pinions. These spiral bevel ring gears and pinions are all made from a fine grain chrome nickel alloy steel known as Krupp steel which has the following chemical composition:

Carbon	Sulphur
.08-.16%	.025 Max.
Manganese	Chromium
.30-.60%	1.20-1.70%
Phosphorus	Nickel
.020 Max.	3.85-4.30%

As previously mentioned in this paper, after machining, these spiral bevel ring gears are carburized to produce an effective case depth of .045" to .060" after which they are reheated to the hardening temperature and quenched in a Gleason Quenching press; followed by tempering at 350°F. to produce a case hardness of 60 - 62 Rc, and a core hardness of 32 -36 Rc.

The spiral bevel pinions are carburized to produce an effective case depth of .045" to .060" after which they are martempered to produce a case hardness of 62 - 64 and a core hardness of 34 - 38 Rc and this is followed by tempering at 300°F.

After grinding, these spiral bevel ring gears and pinions are held to a maximum runout tolerance on the pitch line of .003" which is typical in heavy duty truck axle differential spiral bevel ring gears and pinions.

Fig. 4 shows the loading of a Homocarb furnace with "Four Wheel Drive" heavy duty transmission gears.

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THE HEAT TREATMENT OF FORGINGS

By **A. O. SCHAEFER,** *President*
American Society of Metals
Director of Research
Midvale-Heppenstall Co., Nicetown, Pa.

Fig. 1—Annealing forgings in car-bottom type furnaces.

THE forging industry produces about 3-1/3 million tons of finished product annually, amounting to a mere 4% of the total production of the steel industry. That product in dollars represents a much higher percentage, however, and those of us who are active in forging production believe it should rank even higher in importance because of the unique reliability of the product. Forgings are used in elements of structure in which the engineer must be certain of his material to an extreme degree.

You will note that about 75% of the forgings produced are closed-die forgings or drop forgings. Naturally these in general represent the smaller forgings, although some very large closed-die forgings are made today. The largest forgings are, of course, made in open dies.

A large proportion of the closed-die forgings are made of the AISI Standard Steels, and they are heat treated in much the same way that other steel items of these grades are heat treated. An appreciable proportion of the closed-die forgings are made of the so-called "super alloys", the materials designed for operation at high temperatures in gas turbines, especially in jet plane units. Heat treatment of these materials is fundamentally based on some form of aging. Aircraft construction is also forcing the development of the "ultra high strength steels", some structural members needing all of 280,000 psi Yield Strength. Heat treatment of this material is conventional in principle. The functioning of the alloying elements is to obtain the necessary strength; and, in addition, to make possible tempering in a favorable range.

The very small but disproportionately important field (approximately 1%) of open die forgings represents a segment of the steel industry in which, to a great degree, the individual preferences and prejudices of the metallurgists concerned have full sway. Most of the products may be described as tailor-made. Most of the forgings are produced directly from ingots which, in turn, are cast to order for specific jobs. Hence chemistry can be someone's idea of the optimum for the job; and heat treatment, too, is unorthodox for a variety of reasons.

The heat treatment of steel forgings is not a science set apart from all other heat treatment, but there are phases of the subject which differ from the conventional heat treatment of other steel products. Three phases of the problem that are peculiar to the industry have been selected for discussion in this article. These are:

1. Flakes occur in steel produced by various methods and in various forms, but they are without doubt a major problem to those in the forging industry. The heat treatment of forgings is unique in that an important portion of the cycle has for its prime purpose the avoidance of flakes.
2. Since even the smallest forgings approach what might be called "critical sections" in heat treatment, there is a unique importance in the industry to methods of quenching. Quenching technique is increasingly desired to accomplish transformation in the martensite range.
3. In a great many instances forgings must be machined after heat treatment. It is also true that forgings in service are often exposed to elevated temperatures. They must maintain their dimensions. Heat treatment for stability is an important consideration in the forging industry.

Norman L. Mochel, Manager of Metallurgical Engineering of the Westinghouse Electric Corporation and former President of the American Society for Testing Materials, was asked to give a talk before one of the technical societies in Philadelphia shortly after the close of the Second World War. He was requested to summarize the metallurgical experience of the War Period. One of his principal points was the fact that we had suffered production losses because of flakes to a greater degree than anyone expected in the light of our metallurgical knowledge.

Flakes are peculiarly the dread disease of forgings. Other steel products are known to have flakes, or hair-line cracks, or thermal cracks, or shatter cracks, or fish-eyes, or bright spots, but the larger sections frequently found in forgings, together with the individual handling of forgings makes their occurrence

more frequent, and more spectacular. They are always fatal in forgings which cannot be thoroughly reworked.

The heat treatment of forgings has been correspondingly affected by the necessity of avoiding flakes. While some rolled products are cooled slowly on the hot bed for the avoidance of flakes, and some bar steel receives special heat treatment, in no other field of steel production is so much time and money spent for the avoidance of this defect.

Very early in manufacturing experience, the idea evolved that flakes could be cured by slowing down the cooling cycle after forging was completed. This was often done by burying the forgings in ashes or in some other insulating medium. This is still done, and it is effective in some cases.

The steels used by the forging industry containing various alloying elements are sometimes characterized by a possible spread in the transformation temperatures on heating and on cooling. Specifically the transformation on cooling can be considerably depressed if the rate of cooling is increased. The stresses set up on transformation may then occur when the steel is definitely out of the plastic range and susceptibility to flaking is greatly increased.

For the last quarter century or more we have witnessed the steady increase in the tonnage of alloy steel produced by the basic open hearth process and also by the basic electric arc furnace process. It soon became apparent to those who used steels produced by these methods that they are definitely more susceptible to flaking than that produced by the acid open hearth process. The use of steels produced in basic furnaces necessitated a further readjustment in the practice of avoiding flakes.

During the War Period, it became obvious to the Ordnance Department Gun Committee that the occurrence of flakes was practically unknown to those forge shops which were forging gun barrels from purchased annealed billets. This was not the case in the majority of forge shops which were forging from ingots taken directly from the melt shops and charged into the forge furnaces.

At this time the well known hydrogen theory was prevalent, and the obvious benefits of intermediate heat treament (in this case annealing the billet after forging) were believed to be due to the removal of that pernicious gas, which continues to be one of the more unpopular elements in steel.

Large forgings, or forgings of an alloy steel susceptible to flakes, particularly those of basic open hearth or electric furnace steel were, as a result of this experience, heat treated at an intermediate stage prior to final forging. Such heat treatment in our own plant was called immunizing and usually ran on a cycle like this. The partially finished forging (with appreciable forging reduction still to be accomplished) was taken directly from the die, without being allowed to cool. It was equalized at a temperature of 1200°F., then cooled very slowly under carefully controlled conditions until transformation was completed or to a temperature where transformation will be complete in a reasonable time, then reheated to a tempering temperature and allowed to cool. The prevention of flakes in many forgings was attributed to such heat treatment.

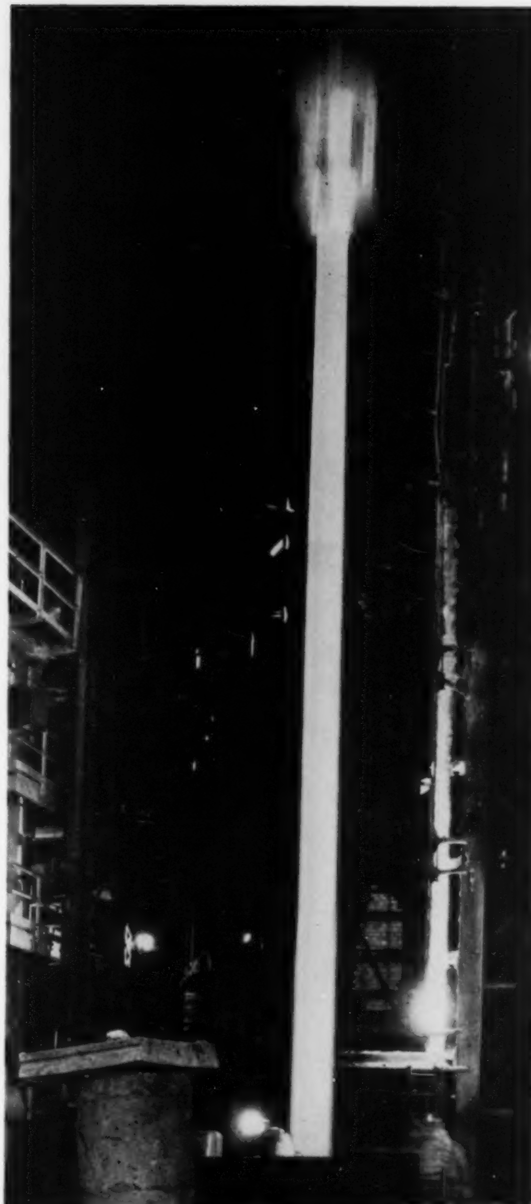


Fig. 2—Liquid quenching gun tube forging.

It soon became apparent that heat treatment introduced between forging operations was not an absolute guarantee against flakes. An effort to make turbine rotor forgings of basic open hearth steel by one manufacturer resulted in 100% condemnations because of flakes although this was and is done successfully in other shops. This occurred in spite of

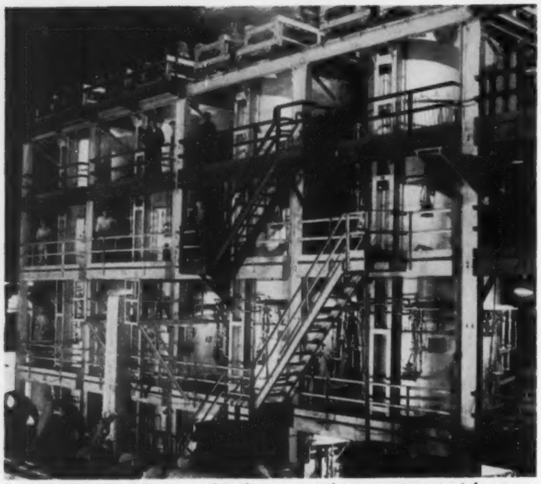


Fig. 3—Gas-fired furnaces for the vertical heat treatment of forgings.

extreme care to avoid flakes. Ingots were forged and given an immunizing treatment similar to that described above. They were re-forged to final dimensions and again given a similar protective heat treatment. Still there were flakes. A number of billets of a type of gun steel (3.50 Ni., 1.00 Cr., and .50 Mo.) were forged, given protective treatment as described and were subsequently examined using ultrasonic equipment. They were not flaked. However, on similar examination of the same billets a month later at destination they were found to be badly flaked. In this case, the subsequent forging was not enough to heal the internal cracks. It is now recognized that we must allow an incubation period before we can state that we have made forgings free from flakes. A month is thought to be ample for this decision, but further data may upset this.

Causes of Flakes

Metallurgical literature on the subject of flakes has been voluminous. There are those who believe flakes are due solely to hydrogen and the stresses causing the cracks are due to this gas coming out of solution in the metal. Others persist in the belief that the stresses are primarily due to the volume changes incident to transformation, the role of hydrogen being merely that of any embrittling element that might be present in the steel. Stresses due to temperature gradient in cooling forgings have been cited as the cause of flakes. Among the notable investigations into the causes of flakes, Dr. Troiano of Case Institute of Technology is preeminent in this country at the present time. A substantial installment of his work appeared recently in the *Journal of Metals*. There are indications that the completed work will be of the greatest importance to the forging industry. Dr. Troiano's conclusions as given in the *Journal of Metals* are worth noting:

1. Hydrogen is necessary for flake formation. Further data is needed to establish what level of hydrogen may be considered dangerous.
2. Transformation stresses also must be present. No flaking will occur if the decomposition of austenite is completed above the MS point prior to cooling to room temperature.
3. The greatest tendency for flaking is found in mixed structures and very little martensite need be present.
4. In such mixed structures no correlation appears to exist between the tendency for flake formation and the average hydrogen content of the steel.
5. Flake cracks in predominately martensitic structures are usually radial.

Preventive Heat Treatment

Present day preventive heat treatment is based on the following principles:

1. Forgings must not be allowed to cool from the forging operation either too rapidly or in an uncontrolled manner. Therefore, they are usually taken hot from the forge and charged in heated furnaces (at about 1200°F.) and equalized. They are cooled under control not faster than 30°F. per hour.
2. Forgings are then allowed to transform completely while still warm, usually in a range of 450°F. to 600°F., aimed to be a little above the MS temperature. This temperature is also considered to favor the loss of the largest possible amount of hydrogen.
3. They are then reheated to a temperature above the transformation range, if they are to be stocked, or held for machining. This accomplishes the refinement of the structure resulting from forging, putting it in better condition to withstand successfully any stresses that will be brought about by subsequent cooling.
4. Following controlled cooling, and soaking again at an intermediate temperature for transformation, they are heated to a tempering temperature to soften them and minimize the stresses residual from the normalizing heat.

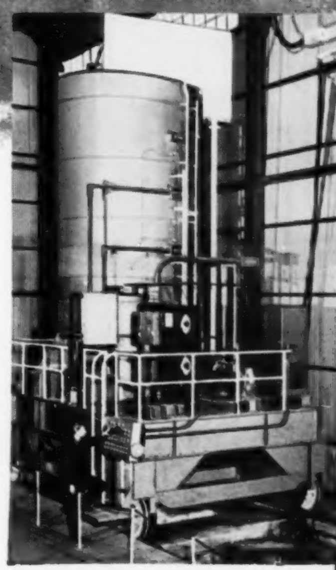
The history of the occurrence of flakes in forgings indicates that constant vigilance is needed if a manufacturer wishes to stay out of trouble. Even then, there will be occasional flakes and occasional epidemics of flakes. If we were certain that vacuum pouring technique could make it sure that we would not have flakes, it would be generally adopted in the forging industry.

An increased appreciation of the importance of quenching technique as applied to steel forgings might well be considered to be an outgrowth of the war.

It is true that quite large forgings were liquid quenched prior to this time, but the entire conception of quenching contained large areas in which whatever knowledge we had was purely empirical. Forged die blocks were quenched but they were and still are considered to be a very special product. Large forged rolls were liquid quenched, but here again the harden-

(Continued on page 20)

Metallurgical, Inc. chooses
Armour Ammonia
when heat treating jet plane parts!



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Air Force specifications call for extremely close tolerances and the ultimate in structural strength and durability. Metallurgical, Inc. has found that the dryness and extreme purity (99.98%) of Armour Ammonia is a prime factor in obtaining such results.

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T9

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REPORT ON TITANIUM

By **S. R. CARPENTER**, *Engineer,*
Convair Division,
General Dynamics Corporation,
San Diego, Calif.

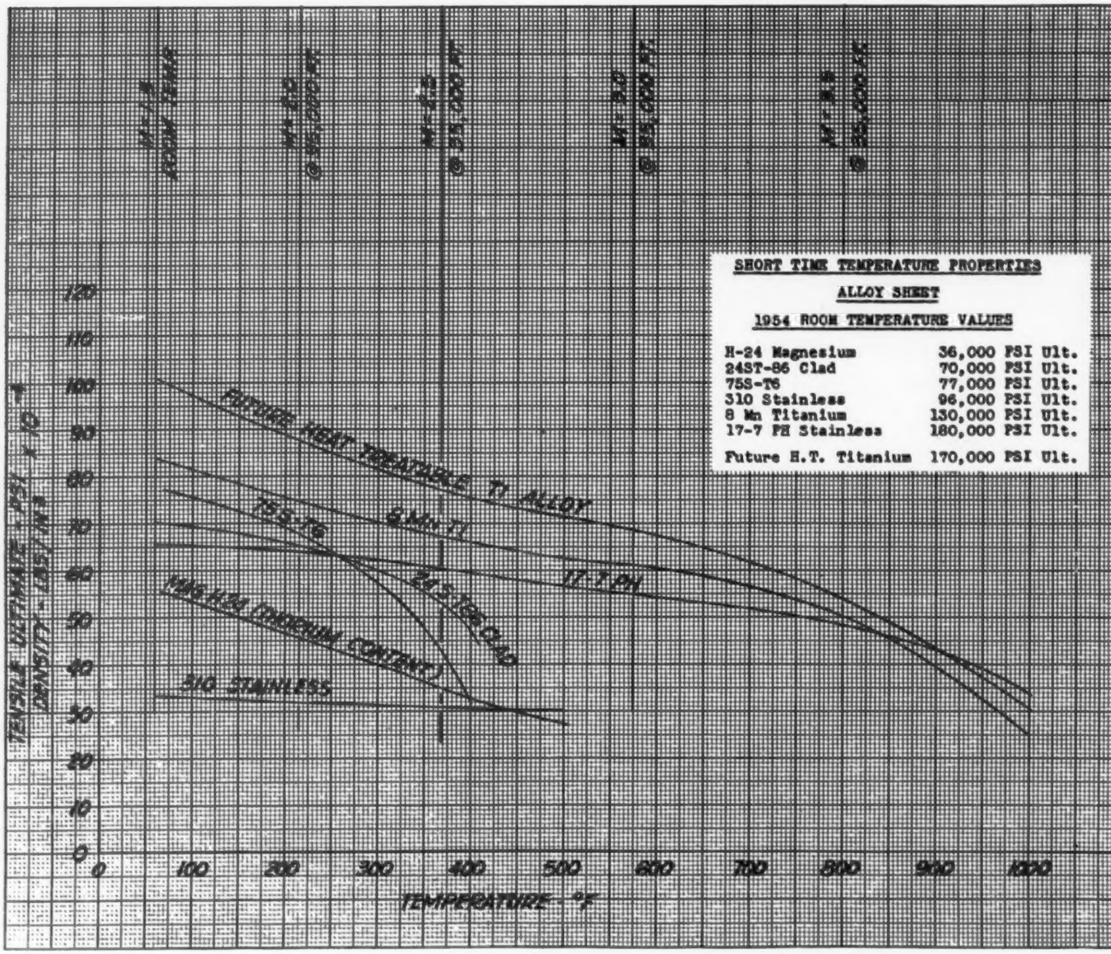


Fig. 1—Short time temperature properties of alloy sheet at 1954 room temperature values.

DESPITE skeptical statements which are still being made with regard to its merits, titanium is now regarded as a necessity by those of us who must think in terms of aircraft capable of exceeding the speed of Mach 1.5.

The reasons for this are briefly summarized by data in Figures 1 and 2.

Fig. 1 shows the ultimate tensile relationship on a strength/weight basis of some familiar aircraft sheet materials. Note how rapidly aluminum alloys deteriorate with temperature. Between Mach 2 and 2.5 at altitudes where temperature approaches 300°F., they are rapidly diving out of their useful range. Above 300°F., other materials must take over to avoid weight penalties. A typical steel at 180,000 psi begins to show advantages over aluminum and magnesium above 275°F., but the present 8Mn titanium alloy takes a prominent position over the best of the illustrated materials.

The Fig. 1 comparison is slightly optimistic because the curve is set up for typical strengths of 130,000 psi ultimate, despite existing guarantees of 120,000 psi, but present titanium alloys still have an advantage in tensile strength above 200°F. Further, it should be noted that 8Mn and Ti-140A alloys are comparatively low-strength materials which leave much to be desired as far as the potential of titanium is concerned. The heat treatable alloy, shown at 170,000 psi in Figure 1, is a better indication of what titanium can do; but materials of this type are still in pilot production.

Relative merits of wrought materials for fittings and extrusions are illustrated in Fig. 2, and here the advantage of Republic Steel's heat treated RS-140X

at 196,000 psi should be noted. Preliminary heat treatment tests conducted by Convair show we can expect a design allowable of about 180,000 psi and yet the 196,000 psi for RS-140X is probably only typical of what we can expect in the future!

Also worth noting in Fig. 2 is the relationship of heat treated titanium and the "superalloy" steels. The latter cannot compete in most applications, even at room temperature, and they must be used with caution above 450°F.—where their drawing temperatures begin. But titanium alloys can already be used at temperatures up to 800°F.

It is encouraging to note that much progress has been made in the heat treatment of titanium alloys. However, it stands to reason that considerable research in this field remains to be accomplished.

Best-known at present are duplex heat treatments whereby materials are solution treated in the range of 1500° to 1750°F., depending on the alloy in each instance, and then rapidly quenched and aged at 900° to 1000°F.

One aging treatment, which increases the strength of the 6A1-4V titanium alloy, is indicated in Fig. 3. It has been used to attain 165,000 psi ultimate tensile strength. Ultimate tensiles of 177,000 psi have been obtained with the same alloy where the latter was heated at 1750°F. for one hour, water-quenched, and aged at 900°F. for 24 hours.

Unfortunately, the attractive properties acquired in both of the latter instances must be revised down to 155,000 and 167,000 psi for design purposes—since it is necessary to make an allowance for the change in mechanical properties due to heat treatment and add it to the minimum guarantee for the alloy in the annealed condition in each case.

If aging curves for all heat treatable titanium alloys were now available and similar to those in Fig. 3, it would no doubt be desirable to limit aging time to six hours in order to minimize the need for furnace capacity and simplify production problems by permitting each aging operation to be completed in the course of an eight-hour work shift. However, longer aging intervals may have to be specified in order to gain certain design advantages in processing a number of titanium materials.

The details of Fig. 4 should be especially interesting to anyone who has worked with stretch-formed titanium, due to the low yield/ultimate ratio indicated.

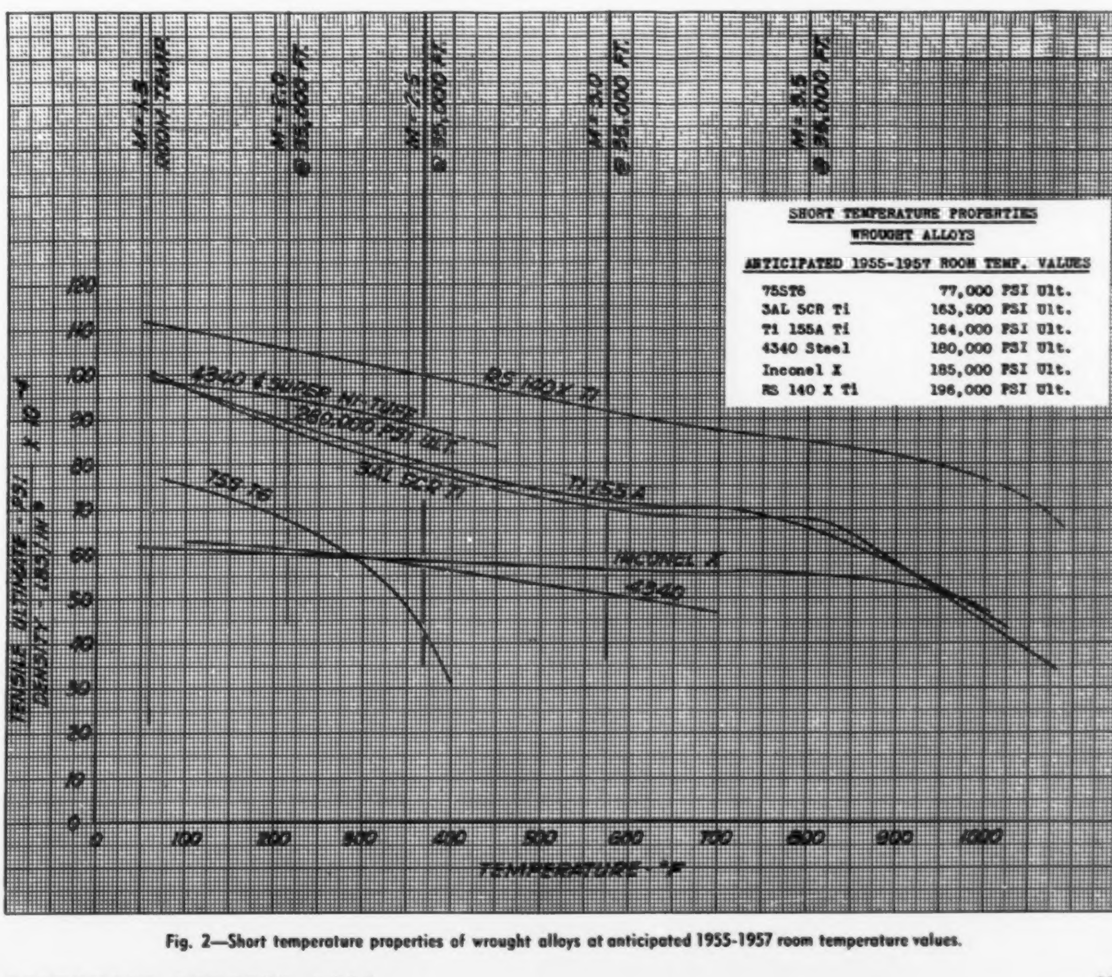


Fig. 2—Short temperature properties of wrought alloys at anticipated 1955-1957 room temperature values.

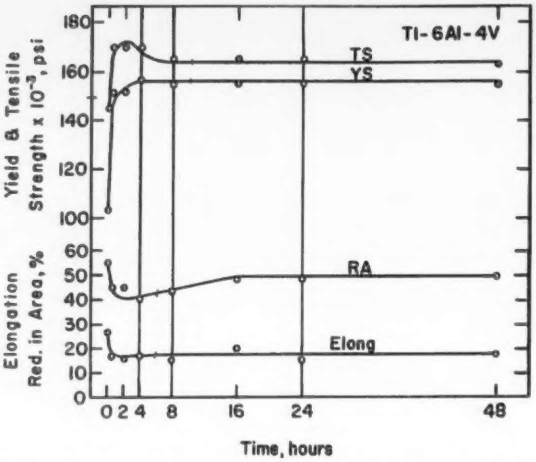


Fig. 3—Effect of aging time at 900°F. on tensile properties of specimens solution treated at 1550°F. *Data from Titanium Metals Corp. of America.*

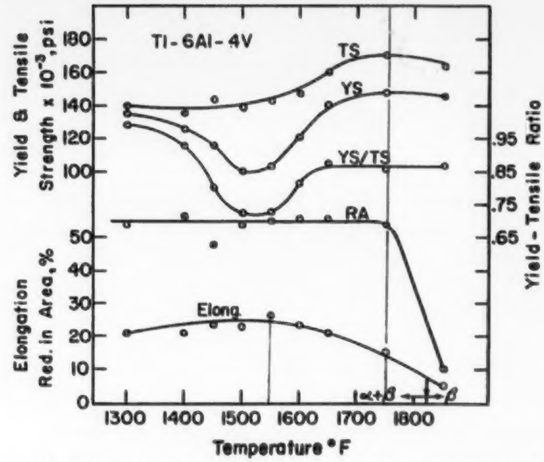


Fig. 4—Effect of solution temperature on tensile properties. *Data from Titanium Metals Corp. of America.*

High yield/ultimate ratios (up to .95) have to date presented a special problem in work with titanium sheet angles, zees, and channels because they allowed machine operators small margins between material yield and breaking points. The low yield/ultimate of .71 shown in connection with a 1550° solution heat treatment permits a stretch machine operator to use a variety of pressures above yield strength, and even the yield/tension ratio of .87 noted for the higher strength level is in a very workable range.

Titanium producers could earn a vote of thanks from the aircraft industry at present by manufacturing solution-treated sheet stock, since fabricators cannot cope with straightening problems in large sheets. The low yield/ultimate ratio of solution treated sheet would facilitate forming (especially with low-power machines), after which high-strength parts could be attained by means of a simple aging process.

Due to the Baushinger Effect, there is a very pronounced loss in compression yield after titanium is

(Continued on page 53)

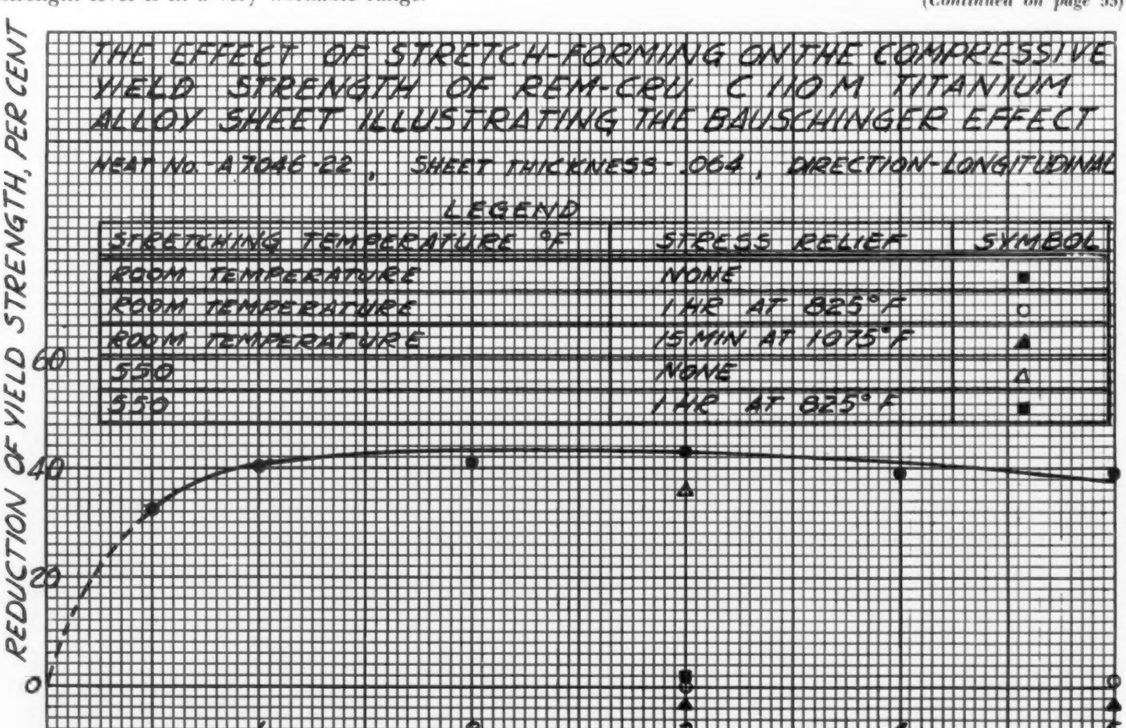


Fig. 5—The effect of stretch-forming on the compressive yield strength of Rem-Cru C 110 M titanium alloy sheet illustrating the Bauschinger effect.

HEAT TREATING HELP

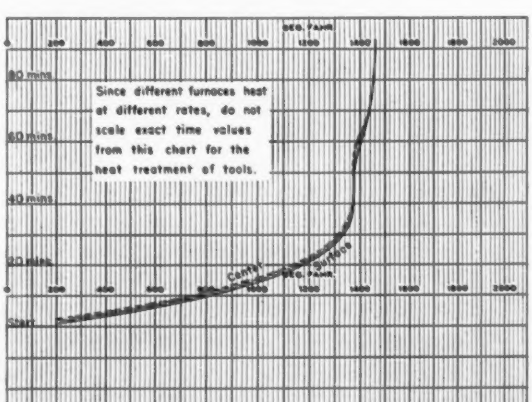
THE CARPENTER STEEL COMPANY, 198 W. Bern St., Reading, Pa. No. 1 in a series

SIMPLIFIED HEAT TREATMENT

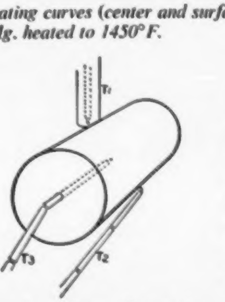
The heat treatment of Carpenter Matched Tool and Die Steels has been simplified beyond anything previously known. Instead of leaving "up in the air" such important items as *speed of heating, furnace atmosphere, temperature for drawing, time for drawing, etc.*, we have done a thoroughgoing research job on these details. We are publishing this information in the sincere hope that it will enable the tool hardener to get with certainty the results he wants.

SPEED OF HEATING FOR HARDENING

It has always been assumed that a piece of tool steel heats much more rapidly on the surface than at the center, and that the *outside* might be fully up to the temperature of the furnace while the center was still "black". This is *not* true. Regardless of the mass of the piece, when the entire outside surface is up to furnace heat, the center is up to heat also. The pyrometer chart reproduced below proves this.



Heating curves (center and surface) for tool steel specimen 3" rd. x 6" lg. heated to 1450°F.



Illustrating shape of specimen, and placement of thermocouples for measuring rate of heating.

Shown to the left is a piece of tool steel 3" round and 6" long, with one thermocouple (T_2) fastened to the outside surface, and another (T_3) buried at the exact center of the piece. The thermocouple (T_1) which controls the furnace temperature is maintained steadily at 1450°F throughout the entire heating cycle. Note on the pyrometer chart that the center lags behind somewhat in the early stages of heating, but during the last 30° the center and surface move exactly together. The first rule of heating then is this—

Rule 1—Heating Time

Have the furnace thermocouple close to the tool so that both can be seen in one "eyeful". When the entire tool exactly matches the color of the thermocouple, soak 5 minutes per inch of diameter or thickness, and then you can be sure the entire tool is uniformly up to heat.

"... both can be seen in one 'eyeful' ..."

Note:—*The only exception to this rule is on Vega (Air-Tough) on which a 20-minute soak at temperature is recommended, followed by 5 minutes per inch of thickness.*

A second point—it has always been emphasized that tools should be heated *slowly*—even preheated if possible. This is supposed to inhibit warpage and cracking. We recommend such preheating *only* on High Speed Steel. All other Matched Tool and Die Steels should be allowed to heat "naturally". By this we mean—

Rule 2—Heating Speed

For all Carpenter Matched Tool and Die Steels that harden under 1900°F, first get the furnace running steadily at the proper hardening temperature. Then, without preheating, put the cold tool right in on the hot hearth (near the thermocouple) and let it heat "naturally" as fast as it will.

Note:—*Tools that have been previously hardened should be annealed before rehardening.*

Because of the "timbre" characteristics of Carpenter Matched Tool and Die Steels, we can truthfully say that "natural" heating is not only *permissible*—but it is actually *desirable*. This simple rule eliminates all worry on the part of the hardener as to "How long should I take to heat the tool?". Just put it in the hot furnace and *watch* it. The tool will tell you how long it takes. You merely follow Rule 1.

In this first issue of "Heat Treating Helps" we have discussed the "Speed of Heating for Hardening". In future issues of this magazine we plan to continue the discussion, outlining additional data on considerations such as "Time Required to Reach the Drawing Heat", "Hardening Furnace Atmosphere", "Quenching Procedures", etc.

THE HEAT-TREATMENT OF STEEL

By **PROF. C. A. SIEBERT,** *Metallurgical Engineer*
University of Michigan, Ann Arbor, Mich.

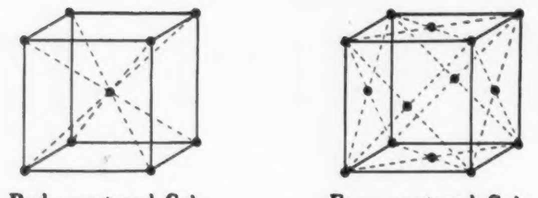


Fig. 1—Arrangement of atoms in iron from room temperature to 1670° F. (left), and from 1670°-2535° F. (right).

THE metal iron has the atoms arranged in a body-centered cubic lattice from room emperature to 1670°F, and in a face-centered cubic lattice from 1670°F. to 2535°F., as shown in Fig. 1. Carbon dissolves rather readily in the face-centered cubic lattice but only to a very slight extent in the body-centered cubic lattice. It is this difference in solubility of carbon in the two phases of iron which accounts for the fact that steel can be heat treated.

It is necessary to consider the equilibrium conditions of the iron carbon system in order to appreciate the non-equilibrium conditions which exist in hardened steel. Fig. 2 shows a portion of the iron-carbon equilibrium diagram. There is a eutectoid (pearlite) at 0.83 percent carbon which forms from the solid solution of carbon in face-centered cubic iron (austenite) at a temperature of 1333°F. Pearlite is a mechanical mixture of ferrite (solid solution of carbon in body-centered iron) and cementite (Fe_3C).

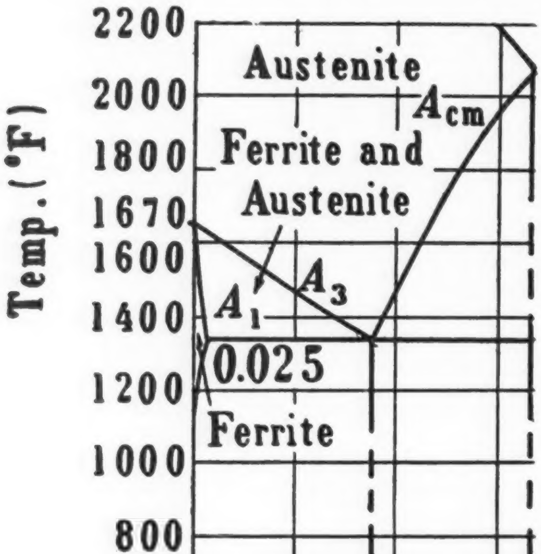


Fig. 2—A portion of an iron-carbon equilibrium diagram.

A 0.5 percent carbon steel, heated to 1600°F. has a microstructure of 100 percent austenite at that temperature. On very slow cooling the austenite would begin to reject ferrite when the temperature reached the A_3 line on the diagram and would continue to reject ferrite until the temperature reached the A_1 line on the diagram. While the temperature was changing from the A_3 to the A_1 level and ferrite was being rejected, the carbon content of the austenite was increasing from 0.5 percent to 0.83 percent, the latter being the eutectoid composition. The Acm line represents the saturation limit of carbon in austenite. Therefore in steels having a carbon content greater than 0.83 percent, cementite would precipitate on cooling, and the carbon content of the austenite would again approach 0.83 percent as the temperature approached 1333°F.

The above illustrates the decomposition of austenite on very slow cooling approaching equilibrium conditions. The non-equilibrium condition associated with the hardening of steel can best be illustrated by considering the isothermal decomposition of austenite at temperatures below 1333°F. Suppose a number of thin wafers of a 0.83 percent C steel were heated to a high temperature where the microstructure was 100% austenite, and then quenched into a molten lead bath maintained at some temperature T_1 which is below 1333°F. Individual specimens could then be removed from the lead bath after varying time intervals, and quenched into water. The process is illustrated in Fig. 3. The time period P_1 was not long enough for the austenite to begin to decompose into pearlite, so on subsequent quenching to room temperature it showed a structure of 100% martensite, (the nature of martensite will be discussed later in this article). Time period P_2 was long enough for some austenite to transform to pearlite, and time periods P_3 and P_4 show an increasing amount of pearlite, while time period P_5 is long enough for all of the austenite to transform to pearlite. It can be seen that the above process depends upon nucleation and diffusion, with the nuclei of pearlite (ferrite and cementite) forming at the austenite grain boundaries. As the temperature T_1 is lowered the pearlite be-

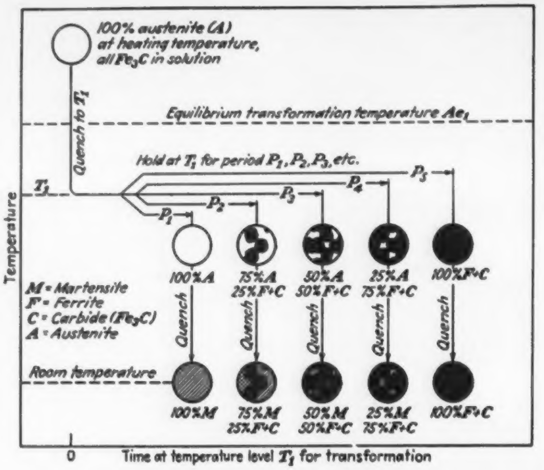


Fig. 3—Heat treating cycles employed in studies of isothermal transformations. Courtesy of Pitman Publishing Corp.

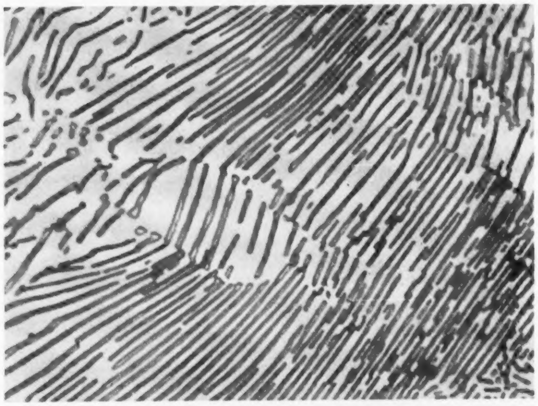


Fig. 4—Coarse pearlite formed at 1300° F. (705° C.). Magnified 2000 times. Courtesy of Pitman Publishing Corp.

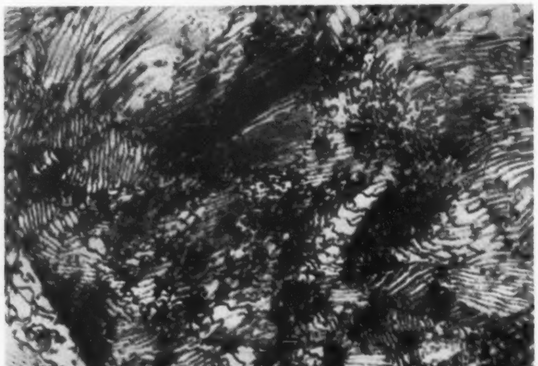


Fig. 5—Fine pearlite formed at 1185° F. (640 C.). Magnified 2000 times. Courtesy of Pitman Publishing Corp.

comes increasingly finer in texture, as shown in Figs. 4 and 5.

Repeating the above experiment at various temperature levels would result in the accumulation of data for the beginning and ending of austenite decomposition at the various temperature levels. The

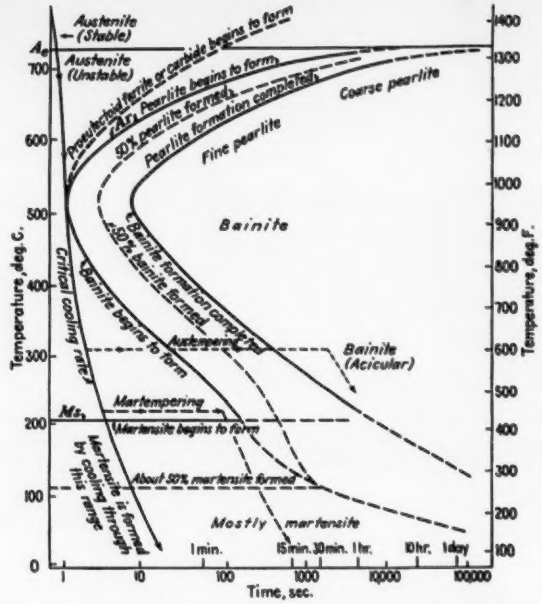


Fig. 6—Schematic T-T-T diagram for carbon steel showing critical-cooling-rate curve, M_s temperature, and temperatures for austempering and martempering. Courtesy of Pitman Publishing Corp.

data could then be plotted as a conventional time-temperature-transformation (T-T-T) diagram. The T-T-T diagram shown in Fig. 6 is a schematic diagram for carbon steels and includes the proeutectoid line for ferrite and carbide, which applies to steels of less than or greater than 0.83% C respectively. Attention is called to the fact that the proeutectoid line joins the beginning of pearlite transformation line at approximately 1000°F. This means that only pearlite would be present when fully transformed at this temperature, regardless of the carbon content of the steel, and the carbon content of the pearlite in any steel other than 0.83% C can only have that value when transformed at 1333°F.

The transformation of austenite by isothermal decomposition below the knee of the diagram (1000°F.) results in the formation of a microstructure, distinctly

Fig. 7—Bainite formed at about 700° F. (370° C.). Magnified 2000 times. Courtesy of Pitman Publishing Corp.

(Continued on page 42)

CONTROLLED ATMOSPHERE GEAR CARBURIZER IMPROVES QUALITY and INCREASES PRODUCT DEMAND

By E. G. LINDGREN, *Executive Vice President*
Brad Foote Gear Works, Inc.
Chicago, Illinois

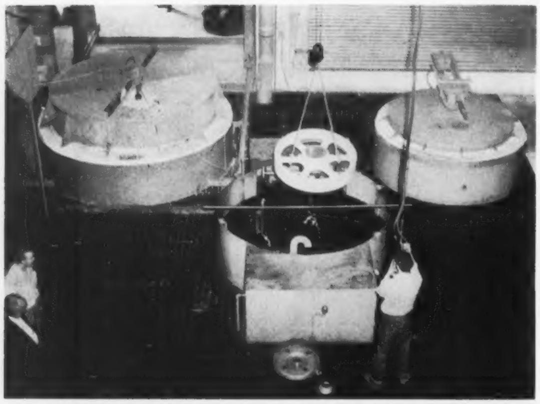


Fig. 1—Overhead view showing carburizing furnace in left rear, draw furnace in right rear, and quench system in center. Furnaces were built by Standard American Engineering Co., Chicago, Ill.

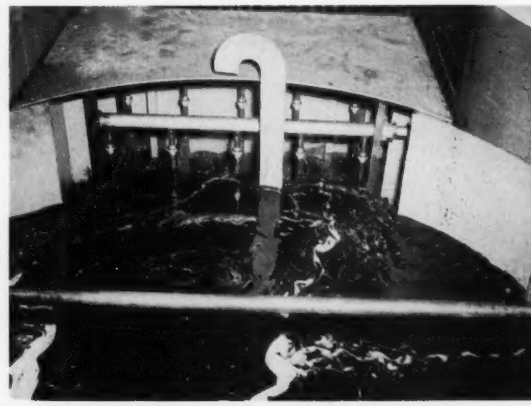


Fig. 2—A close-up showing extreme agitation of quench oil in the quench system.

PITTSBURGH Gear Company, a subsidiary of Brad Foote Gear Works, Inc., has installed what is presently considered to be the largest radiant tube pit-type gas carburizing furnace ever built. The furnace is being applied to improve quality control further; to increase production of Pittsburgh Gear Company's products; and to widen the range of available gear sizes to include diameters of over six feet.

Design considerations involved the "job shop" characteristics of Pittsburgh Gear Company's manifold heat treatments as required by the variety of their gear products. While deep case carburizing was the primary objective, it was also necessary to provide for such operations as normalizing, annealing, hardening, stress relieving, carbon restoration and dry cyaniding in controlled atmosphere.

The carburizing furnace installed as a result of the above considerations has proven itself on most of the above operations. It has a work chamber over six feet in diameter by six feet deep, and will handle maximum loads up to 8500 pounds. A volume-type fan is employed to circulate the carburizing or other controlled atmosphere and improve temperature uniformity within the furnace work area.

A dome type refractory lined steel cover is lifted by air, and removed to the rear of the furnace by an electrically powered chain drive with speed reduction.

The furnace is heated by the Davis Radimatic recuperative-type radiant tube, the efficiency of which is indicated by the relatively low maximum input rating of one million b.t.u. an hour. Operating temperature is regained within two or three hours after reloading.

By reason of the low thermal requirements, it has been economically desirable to idle the furnace at 1500°F. over weekends to maintain longest refractory and alloy life.

Accurate control of carbon penetration and carbon potential is achieved through use of carrier gas supplied by an endothermic generator. Metered quantities of natural gas are added as determined by furnace dew point reference. It has been found that carbon concentration of parts being treated closely approaches that of standard dew point-carbon curves. The natural gas volume is varied to obtain desired case depth and carbon concentration as indicated by timed readings with a dew point instrument.

Well into its first year of operation, the furnace has already shown satisfactory results and has proved itself in carburizing parts of varying size, cross-section, case depth and carbon concentration in one load. Metallurgical properties are easily held within the most rigid specifications of Brad Foote's "Certified" gear line as supplied on some of the most exacting contract requirements of the government.

In addition to the quality and production features, many other advantages over the pack method have been realized, such as:

a. Substantial savings in floor space.
b. Simplified, cleaner inspection.
c. Cleaner housekeeping.
d. Improved working conditions.
e. Elimination of storage, repair and constant re-sizing of carburizing boxes.
f. Elimination of storage and handling of carburizing compound.

Success of the new installation is such that the present pack carburizing furnaces are being removed from the plant.

Effective and safer quenching is accomplished in a generally rectangular shaped steel quench tank large enough to hold the total quench and storage oil requirements without separate reserve tanks. Through each end of the tank is installed a propeller-type agitator providing about 10,000 gallons a minute total circulation or a complete oil change twice a minute.

Water coils, suspended within the tank in the path of the oil circulation, cool the oil as required. The oil temperature is controlled by means of a thermometer-type recording instrument.

The draw furnace is of the "Radivection" type providing combined effects of radiation and convection heating to assure rapid uniform heating and accurate control of finished gear hardness. ■ ■ ■

HEAT TREATMENT OF FORGINGS

(Continued from page 8)

ing of rolls represented a treatment designed to develop desired surface hardness rather than homogeneous properties for structural application. Tons of forged armor were made and heat treated in this way for the old battleships and dreadnaughts.

Forgings for other applications were liquid quenched. In Europe, we were told that the forging industry commonly liquid quenched large turbine and generator rotor forgings. We also heard that several catastrophic failures of such forgings occurred there and we attributed this to their dangerous heat treatment practices. Cannon barrels were liquid quenched. The equipment necessary to heat vertically forgings 75 feet long for 16-inch naval rifles existed in relatively few plants. It was frequently used to illustrate heat treatment as applied to large forgings, at least the more sensational part of it. It should be noted that, at first, carbon and nickel steels only were commonly quenched in water. Nickel chromium, nickel chromium molybdenum, chrome vanadium, and chrome molybdenum steels, were usually quenched in oil. It was commonly considered that they could not be quenched in water without cracking.

Selection of Alloy Steel

The problems of selections of the proper alloy steel and the conservation of strategic alloys must be considered along with the technique of liquid quenching when we are considering forgings.

Prior to World War II, the forging group or at least some portions of it, might well be considered prodigal in the use of alloying elements. It is true that alloys cost money, and that fact had always acted as a restraining influence. They also introduced manufacturing problems. Still we found uses structurally for 5% nickel steel based largely on the fact that 3% nickel steel was tough. Five per cent must be more so. The use of "armor" composition had spread into industry where it was supposed to be great for tough jobs. It was in fact, the forerunner of the AISI 3300 series. The old armor steel contained 3.75% nickel and 1.75% chromium.

The ever changing emergencies presented during the war days necessitated constant vigilance over our supply of alloys and our best efforts for their conservation. The well-known emergency steels were developed and found widespread usage. Boron was found to be valuable in increasing hardenability. The use of rare earth additions was investigated. None of these developments could be applied directly to forgings of the sizes we are discussing but they contributed to corresponding changes in practice which were equally far reaching. This was in spite of the fact that allowances were usually made to permit the largest and most important forgings to be made with sufficient alloy content. There was a concerted program to discover what degree of alloy substitution or elimination could be tolerated.

Coincident with this program was one attempting to improve the properties of a number of critical forgings. War equipment and subsequent peacetime demands have required constant improvement in this direction. The field of forged gun barrels is typical. The importance of mobility and fire power was realized early in the conflict, the African campaign of the British being a fine example. Larger and larger guns were mounted in tanks. Larger and larger guns were mounted in planes. Muzzle velocities were increased. Improved explosives were used. Weight was reduced. Higher strength steels were necessary. The classic studies of Cyril Wells and his cohorts, delving into the variations in transverse tests were later published in our ASM Transactions. They were the basis of much development work.

The problem of forged gun barrels was complicated

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THE RELATIVE IMPORTANCE OF MATERIAL SELECTION *(Continued from page 5)*

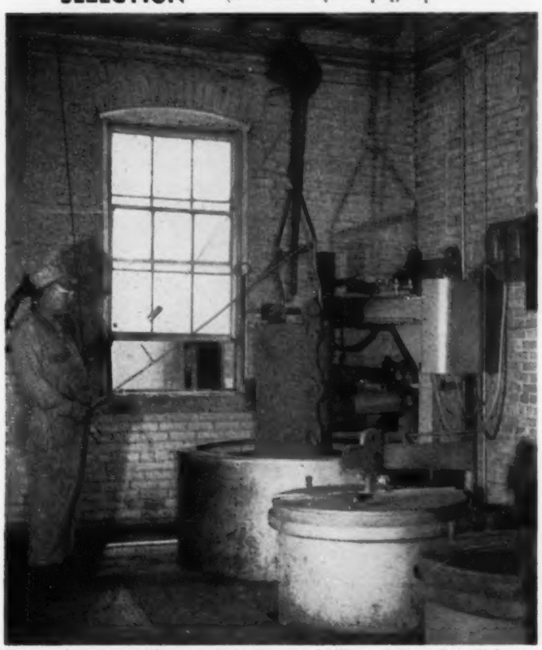


Fig. 4—Loading a Homocarb furnace with "Four Wheel Drive" heavy duty transmission gears.

Conclusion

From the foregoing discussion, therefore, it can be seen that if the producer of the part to be heat treated will cooperate with the heat treater to better their mutual interests to the extent of having the heat treater assist in the specification of the material used in the manufacture of the part to be heat treated, that many benefits will result: namely, difficulties such as excessive distortion or warpage, improper care or case hardness, or excessive or too shallow case depth may be avoided; overall better service performance will be achieved; and a net result of lower overall cost for the producer of the part accomplished.

■ ■ ■

HEAT TREATMENT OF FORGINGS

(*Continued from page 21*)

by severe service conditions. All steels subjected to high temperatures, even for extremely brief times, develop surface checks or cracks in characteristic network patterns. It was important in gun barrels to develop steels in which these surface checks did not progress.

The only criterion that was developed to appraise steel for this quality is the notched bar impact test at low temperatures. The use of this test proceeded from research by Doctors Holloman and Jaffee at Watertown Arsenal, from which it may be said that the choice of alloy and the alloy content must be such that the steel can be quenched in the martensite portion of the transformation curve. The quenching technique must be such that the entire section of the forging is cooled rapidly to accomplish this.

The most generally used criterion for resistance to brittle fracture in forgings has become the transition temperature range of notched bar impact tests. Not everyone is satisfied that this is necessarily the case. The well-known vagaries of notched bar impact testing have plagued industry in many ways, delayed schedules, added the cost of retesting, probably even accounted for the rejection of some good material. In spite of all this, the importance of having this transition temperature as low as possible is responsible for much of the attention being paid to quenching technique.

Alternate methods of appraising the resistance of a steel to brittle fracture include the breaking of notched bend test specimens of varying widths, the deposition of a bead of welded metal on the surface and then bending, micro-examination after polishing and etching by a method which reveals any grain boundaries. None of these methods, nor any other so far, has yielded all of the desired information.

To quench in the martensite range (or even in the lower bainite range, for that matter) requires sufficient hardenability in the steel, and a quenching technique that will extract heat from the piece to be quenched fast enough.

There must be adequate circulation and cooling of the quenching medium. Hollow objects can be more drastically quenched without cracking if the bore surface is thoroughly quenched. In fact quenching a hollow cylinder solely from the bore surface leaves that surface in compression. Some of the most highly alloyed gun barrels were drastically water quenched without cracking by introducing water to the bore surfaces several minutes before it was in contact with the outside surfaces.

Adequate circulation of quenching liquid is necessary to dissipate the heat, and to avoid the formation of vapor pockets on the surfaces to be quenched. This may be accomplished by propellors or by jets. It retards quenching to agitate the liquid with air in the opinion of most. Bores may be quenched by the use

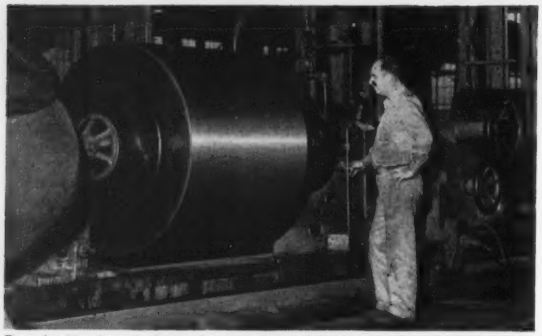


Fig. 4—Hardened sleeve forging mounted on an arbor for a back-up roll.

of submerged jets or by quick fastening hoses applied as the forgings approach the quench tank. When enforced circulation is applied to bores it must be in ample quantity, positively agitated, to avoid the formation of pockets.

Quenching liquids must be kept cool. Systems of adequate volume may be sufficiently cooled with the usual cooling tower or spray tank. In hot and humid climates positive assurance that circulating water will be kept cold can be gained by running it through refrigerating machinery.

Large forgings of chrome molybdenum or chrome nickel molybdenum steels are now successfully drastically quenched. If the alloy contact is sufficient and the technique is good, a martensitic structure results and steel of the maximum toughness is assured.

The third unique feature that has been selected for this discussion is the growing emphasis on dimensional stability.

Machining Operations

Forgings of the type we are discussing are practically always machined after final heat treatment and before being put into use. Machining operations invariably introduce stresses, at least in the surface layers of metal. The severity of the stresses introduced by machining, and their uniformity, and the consequent distortion of the forgings depend to a great extent on the method of machining.

However, internal stresses may be present in forgings which are far more deep-seated. Such stresses may cause non-uniform distortion after machining, distortion when service stresses are applied to the forgings, or they may cause distortion if the forgings operate at temperatures above room temperature.

The rotors used in our steam turbines are somewhat larger than most of the forgings under discussion. However, the industry has learned much from the absolute necessity of producing rotors that will remain straight and stable at operation temperatures.

It will be realized that the rotor of a steam turbine must remain straight at the temperature at which it operates. If it didn't, the very close dimensional differences between the rotating and the stationary blades could not be maintained. Many years ago most rotors were made of carbon steel and little trouble with stability was in evidence.

At the present time, all rotors are made of alloy steels. Nickel molybdenum steel containing about 2.65% nickel and .50% moly is used for some, and chrome molybdenum vanadium steel is used for others. The latter contains 1.25% chrome, 1.00% moly, and .25% vanadium. Several things have been found to be essential to achieve stability in such forgings.

1. The cooling after each normalizing heat or after each quenching heat must be carried to a temperature selected for the grade, and the steel be allowed to transform before reheating.
2. Cooling from the tempering heat must be extremely slow and controlled.
3. The tempering temperature must not be high enough to start the formation of the carbides into a "spheroidized" structure. Such a structure is not stable, the spheroidized carbides tending to grow on heating.
4. For absolute stability, it is necessary to stress relieve after any machining operation.

When these principles are observed the stability of forgings is practically assured.

Heat treatment is one of the major factors in the production of steel forgings. Melting practice, forging technique, and heat treatment are the three principal operations which affect the quality of the forged product. They are equally important. It is only by the integration of all of them that we achieve optimum quality and usefulness. ■ ■ ■

Tool Steel Topics

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation

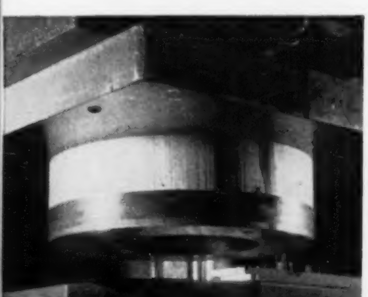
BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

Export Distributor: Bethlehem Steel Export Corporation

Good Results with BTR Hollow-Bar in Manufacture of Fan Housing

Based upon all-around performance — less time spent in machining, good resistance to wear, and ease of heat-treatment — dies of BTR (Bethlehem Tool Room) Hollow-Bar rang the bell recently at Electrolux Corp., Old Greenwich, Conn.; the steel was supplied by Lindquist Steels, Inc., Bridgeport, Conn.

The dies, hardened to approximately Rockwell C 60, and operating in a 100-ton press, formed fan housings from 25-gage zinc-coated sheet steel at the rate of more than 1600 pieces per hour. Redressing was required once every two months or so, and then no more than 0.010 in. was removed.



BTR Hollow-Bar is made from our oil-hardening tool steel by a process called high-speed trepanning. By this method, we take hammer-forged round bars, core the inside diameter, then give them a rough-turning on the outside.

With BTR Hollow-Bar there's no need to run up shop costs waiting for delivery of forged rings or discs. Instead, this fine tool steel comes to you ready to go, with no need for drilling, rough-boring, rough-facing or rough-turning.

Your Bethlehem tool-steel distributor will be glad to explain how BTR Hollow-Bar can be of real service to you. Or a phone call or letter to the nearest Bethlehem sales office will bring you detailed information promptly.

BETHLEHEM TOOL STEEL ENGINEER SAYS:

Remove all the "Bark" from Liquid-Quenched Tools

Most users of tool steel realize that it is necessary to remove the "bark" (scaled and decarburized outer surface) from tool-steel bars in order to obtain full, uniform hardness in heat-treatment. If this area is not removed, low hardness will result because of the low carbon content of the decarburized metal. It is not always recognized that this procedure is necessary on tools which are to be liquid quenched, even though portions of the tool do not constitute working surfaces.

If tools are to be liquid quenched, all the bark must be removed to avoid excessively high quenching stresses which could cause cracking of tools during hardening. Low carbon areas on the surface transform during hardening at a different time than the higher carbon interior. This sets up additional stress which, added to the high thermal stresses from quenching, could cause cracking. Air-hardened tools can tolerate bark on non-working areas because of the low hardening stresses in air hardening. But with liquid-quenched tools there are no exceptions — remove all the bark.

TOOL STEEL MOVIE WINS ANOTHER AWARD

"Teamwork," Bethlehem's new motion picture on tool steel, received a second film award, a silver reel symbolic of excellence, at the recent American Film Assembly competition in Chicago.

The 16-mm, 30-minute color film explains the manufacture, quality control and heat-treatment of Bethlehem tool steels. It is available for showings to machinists, heat-treaters, die makers and tool manufacturers. To see the film, write to Publications Department, Bethlehem Steel Company, Bethlehem, Pa.

Right Or Wrong In LABOR RELATIONS

Editor's Note: *This department presents, in each issue, a round-up of day to day in-plant problems and how they were handled by management. Each incident is taken from a true-life grievance which went to arbitration. Sources of these cases will be given upon request.*

If Some Employees Are On Sick Leave When A Plant Is Closed For Vacation Period, Are They Entitled To A Vacation At A Later Time?

What Happened:

In the interests of efficiency, the company decided to close down the plant for two weeks' vacation. This meant that all employees had to take their vacations at the same time. The management gave the employees plenty of advance notice—two months, in fact. When the shut-down came, three employees were on sick leave. They received their vacation pay like the rest of the employees. However, when they returned, they demanded time off to take their vacation. The company refused to grant the request. The employees were adamant and took the case to arbitration.

The workers argued:

1. Sure, the company had a right to shut down for vacation, but it did not apply to employees on sick, or disability leave.
2. Vacation means a "period of rest and relaxation from work or labor." We were sick and couldn't "relax" during the plant shut-down.
3. We should be allowed to select our vacation period so we could enjoy it when we're in good health.

The company came back with a rebuttal:

1. A vacation is an "earned right" and not solely for "rest and relaxation."
2. The employees accepted pay for vacation so they cannot later protest that they were entitled to time off at a later date.
3. A company cannot make exceptions. The new schedule of plant shut-down was announced in advance and accepted as policy.

Was The Company: RIGHT ☐ WRONG ☐

What Arbitrator Jean T. McKelvey Ruled:

"At the outset the arbitrator finds that there is no question as to the company's right to shut-down for a vacation period. But the question posed before the arbitrator relates to the right of the company to designate the period of the shut-down as the vacation period for employees who because of illness or disability are not able to "take" a vacation. The union wants employees to enjoy a vacation period at some time other than that of their disability. The arbitrator recognizes that the scheduling of vacations is a matter both of company convenience and employee desire. While company convenience may take precedence, despite provision for the exercise of some employee choice, it is hard to see in the matter before us how company convenience was to be served by scheduling off employees who were not in the plant when the vacation shutdown began. Furthermore, there was no evidence presented at the hearing to indicate that the granting of a postponed vacation to the few individuals involved would create a disruption of plant operations. The employees involved in this proceeding have the right to request a postponement of their vacation period. Since pay for these periods has already been received, the company shall grant each employee the vacation period to which he is entitled without additional vacation pay."

If An Employee Is "Displaced" By A Machine Can He Refuse To Take A Lower Paying Job, And Get Severance Pay Instead?

What Happened:

This company had a policy which granted severance pay to any employee who lost his job as a result of "technological change in equipment, method or process" or on account of "removal of machinery or equipment to another area." The severance allowance was one week's pay for every year of seniority.

(Continued on page 34)

"We like this designed-in-service"

says this "HOT ROD" user

General riveters, inc.

[illegible] HERTEL AVE., BUFFALO 7, N. Y.
BEdford [illegible] TWX - BU [illegible]

January 6, 1956

Mr. Warren Davenport
Norton Company
Worcester 6, Mass.

Dear Mr. Davenport:

We are happy to inform you that Norton Crystolon heating elements are giving us excellent service. In an electric furnace built for us by the Edward G. Pierson Co. they have helped eliminate the maintenance we have always experienced with other electric and gas furnaces.

These Norton "Hot Rods" have already lasted over 11,000 hours in operation without a single failure or replacement. The spare elements bought nearly two years ago with the furnace have never been used.

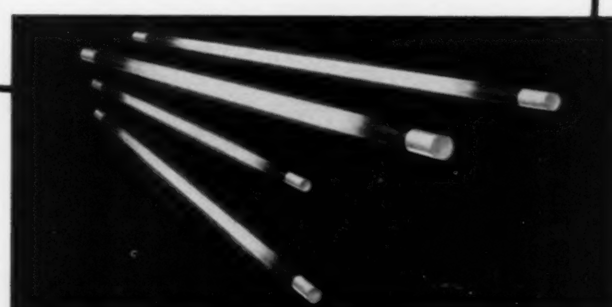
This is the kind of designed-in service we like.

Very truly yours,
GENERAL RIVETERS, INC.

THS/ljk

T. H. Speller,
President

At the Plant Of General Riveters, Inc., in Buffalo, N. Y., this electric furnace, with Inconel muffle and Norton CRYSTOLON* heating elements, is used in heat treating, to bring out the magnetic properties of Vicalloy metal, a component of hysterises type clutches for airborne equipment. Designed and built by the Edward G. Pierson Co. of Grand Island, N. Y., the furnace has given maintenance-free service since its installation over two years ago. The original "Hot Rods" installed are still delivering top performance.



CRYSTOLON heating elements, or "Hot Rods" are a typical Norton R — an expertly engineered refractory prescription for greater efficiency and economy in electric furnace and kiln operation. Made of self-bonded silicon carbide, each rod has a central hot zone and cold ends. Aluminum-sprayed tips and metal-impregnated ends minimize resistance and power loss. Available in standard sizes and interchangeable with your present rods.

Proved "Hot Rod" Advantages

You save in element costs, because you use far less "Hot Rods." Many plants report they outlast other non-metallic heating elements *up to 3 to 1!* This also means less maintenance time spent in changing elements and voltage taps. Also, "Hot Rods" heat more uniformly, due to their slow, evenly matched rate of resistance increase. This helps protect product quality and maintain a smooth production flow.

For further facts on how "Hot Rods" can help improve your furnace operations and cut costs, send for booklet, *"Norton Heating Elements."* NORTON COMPANY, Refractories Division, 628 New Bond Street, Worcester 6, Mass.

*Trade-Mark Reg. U. S. Pat. Off. and Foreign Countries

NORTON

REFRACTORIES

Engineered... R... Prescribed

Making better products... to make your products better

NEWS TO HEAT TREATERS...

DUCTILITY TESTER

A "push-button" demonstration of ductility testing of sheet metal will be one of the featured attractions in the Metal Show Booth (No. 1324) of Steel City Testing Machines, Inc., Detroit. The display unit shown here is being brought to Cleveland direct from a summer showing at the Ford Rotunda as a part of the exhibit of the Bethlehem Steel Corp. The visitor is invited to press a button which automatically puts the machine through one testing cycle.

Steel City also will exhibit for the first time two new models. A new motorized hydraulic bench type Brinell hardness tester combines ease of operation with economy of low initial cost. A new ductility tester is designed especially for testing thin metals in a range from .003" to .062" in thickness.

Other Steel City products to be shown in operation include "Color-Glance" production type Brinell hardness tester, dead-weight type Brinell hardness tester, Portable Hardness Testing Hammer, proving rings, Flex-Tester for checking drawing qualities and stretcher strain characteristics of cold-roll steel, and miscellaneous accessories.

For further information circle No. 1

HEAT TREATING SEMINAR AT METAL SHOW

Widespread requests by users of heat treating equipment for a practical, down-to-earth review of the newest developments in the use of protective atmospheres are being answered by a special intensive session on the subject at the National Metal Congress in Cleveland this fall.

The Industrial Heating Equipment Association announces that a special seminar on protective atmosphere furnaces has been set for 9:00 A.M. Tuesday, October 9 in the Statler Hotel Ballroom.

"Developments in protective atmospheres have come so rapidly that many users of this equipment have felt the need of a 'catch up' session," Carl L. Ipsen, Executive Vice President of I.H.E.A. said. "This program is aimed at acquainting interested persons with the great opportunities for increasing production, for better quality control, and for lowering costs that modern atmosphere furnaces offer."

There will be six papers on the subject, Ipsen said. Each has been prepared on an industry-wide basis by I.H.E.A. members, with all member companies contributing their latest information to each.

Subjects covered and speakers will be:

"Furnace Atmospheres — Their Selection and Application" by C. H. Vaughan, sales manager, Electric Furnace Company, Salem, Ohio; and C. E. Peck, engineer, Industrial Heating Division, Westinghouse Electric Corporation, Meadville, Pennsylvania.

"Furnace Atmospheres — Their Control", will be presented by Walter Holcroft, Executive Vice President, Holcroft and Company, Detroit; Wayne Besselman, Leeds and Northrop Company, Philadelphia; and O. E. Cullen, chief metallurgist, Surface Combustion Corporation, Toledo, Ohio.

"Atmosphere Furnaces — Their Safe Operation" will be presented by Norman H. Davies, President, North American Manufacturing Company, Cleveland, chairman of the I.H.E.A. committee on safety.

ARMOUR AND CO., APPOINTMENT

John L. Lambur has been appointed sales supervisor of jobbers and agents for the Ammonia Division of Armour and Company, R. S. Passmore, Division manager, announced.

Mr. Lambur, who will be headquartered in Chicago, was formerly district representative at St. Louis where he joined Armour in May, 1955.

Previously, Mr. Lambur was regional sales manager for Ozark Airlines.

OUTLOOK FOR INDUSTRIAL HEATING

An annual sales volume of more than $200 million by 1965 has been predicted for the industrial heating industry by a General Electric Company executive.

Speaking at the dedication of the company's new Industrial Heating Department plant at Shelbyville, Indiana, Earl W. Cunningham, department general manager, stressed the trend to more continuous automatic heat treating in every phase of industry. Practically every product in use today, in the home or in

industry, has been heat treated in some way during its production, he pointed out. It is only natural, then, that heat treating will become more and more mechanized as the nation's consumption of every type of product increases.

"We can also look forward to considerable improvement in other processes. Vacuum arc melting, currently used with metals such as molybdenum, zirconium, and titanium, will be utilized more and more with plain steels for special applications and high alloy steels. Equally important, this process will increase the array of available metals and alloys that have superior mechanical and chemical properties and offer high corrosion resistance, great strength at elevated temperatures and improve workability," he said.

In the final processing of metals vacuum heat treatment will permit more exacting control as well as improve their workability and service life.

In the field of brazing, the use of protective atmosphere gases and vacuums will simplify, and in many cases provide the only method, for joining metals and ceramic-metals for higher temperature use, he commented.

Now in use, and becoming widespread in large plants in the foreseeable future, are systems for centralized protective atmosphere production, to provide atmosphere gases for use in different locations throughout a plant.

"There will be a corresponding development of furnace equipments which will provide faster heat-up, higher temperatures, continuous operation, with completely automatic, more precise control."

Mr. Cunningham pointed out that it is this outlook for the industrial heating industry and its processes that was responsible for General Electric's decision to build this new plant. The new $5 million plant, under construction since early 1955 and completed recently, consolidates all of the industrial heating manufacturing facilities of the company at Shelbyville. With a total area in excess of 245,000 square feet, the new facility is producing some 50 types of industrial heat processing equipments, heater components, and devices. They range in size from five-story, tower-type strip annealing and galvanizing furnaces to a two-ounce soldering iron. (See photo.)

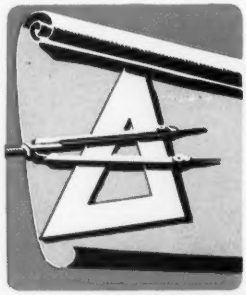
The plant also includes a 12,000 square foot research laboratory devoted exclusively to product research, testing, and metallurgical analysis. In the past, the company's laboratory of this type was largely responsible for the development of such now standard processes as furnace brazing, protective atmosphere gas producers, electric snowmelting equipment for railway switches, and the development of metal sheath heaters.

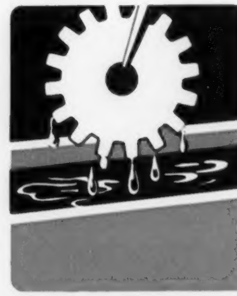
(Continued on page 32)

6 reasons for checking you

HE PROVIDES . . .

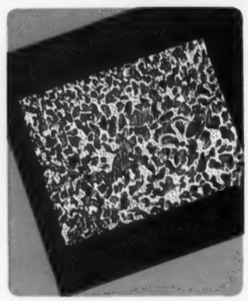
1 **Guidance in Steel Selection and Design**

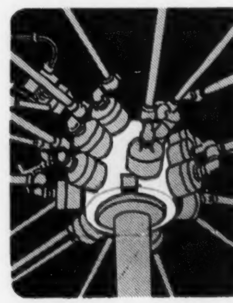




4 **Knowledge throu Experience of th Right Heat Treat for the Job**

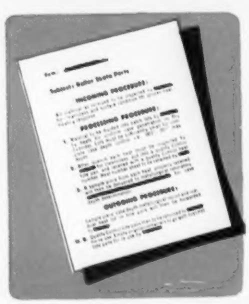
2 **Metallurgical Understanding of Metal Properties**

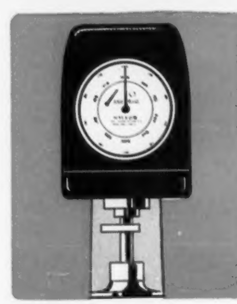




5 **Extensive array of Equipment and Facilities**

3 **Assistance in Proper Preparation of Parts for Heat Treating**





6 **Final Laboratory and non-destructive Testing**

Whenever your production requirements for a new product or the redesign or improvement of an old one mean the installation or expansion of heat treating activities, it will pay you to check with your Commercial heat treater before tackling the job yourself.

The 6 basic reasons for this are shown above.
Remember the Commercial Heat Treater has the skill, the experience, the equipment;—all under one roof ready to serve you.

MTI MASTER CRAFTSMEN METAL TREATING INSTITUTE

METAL TREATIN

Commercial Heat Treater first!

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CALIFORNIA

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ndberg Steel Treating Co.
2910 S. Sunol Drive, Los Angeles 23
alloy Heat Treating Co.
11648 So. Atlantic, Lynwood
ok Induction Heating Co.
4925 East Slauson Ave., Maywood
dustrial Steel Treating Co.
1549—32nd St., Oakland 8

COLORADO

etal Treating & Research Co.
4110 Fox St., Denver 16

CONNECTICUT

ommercial Metal Treating, Inc.
89 Island Brook Ave., Bridgeport 6
anley P. Rockwell Co.
296 Homestead Ave., Hartford 12

ILLINOIS

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124 S. Batavia Ave., Batavia
ccurate Steel Treating Co.
2226 W. Hubbard St., Chicago 12
ura-Hard Steel Treating Co.
2333 West Deming Place, Chicago 47
earson Industrial Steel Treating Co.
5757 W. Ogden Ave., Chicago 50
erfection Tool & Metal Heat Treating Co.
1756 West Hubbard St., Chicago 22
ed A. Snow Co.
1942 West Kinzie St., Chicago 22
merican Steel Treating Co.
P. O. Box 225, Crystal Lake
klund Metal Treating, Inc.
721 Beacon St., Loves Park
ndberg Steel Treating Co.
1975 No. Ruby St., Melrose Park
T. Muehlemeyer Heat Treating Co.
1531 Preston St., Rockford
U. Scott & Son, Inc.
1510 First Ave., Rock Island

MARYLAND

aryland Tool Company
111-13 Hollingsworth St., Baltimore 2

MASSACHUSETTS

w England Metallurgical Corp.
475 Dorchester Ave., South Boston 27
rter Forge & Furnace, Inc.
74 Foley St., Somerville 43
eenman Steel Treating Co.
284 Grove St., Worcester 5

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Bosworth Steel Treating Co.
18174 West Chicago Blvd., Detroit 28
Commercial Steel Treating Corp.
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Commonwealth Industries, Inc.
5922 Commonwealth Ave., Detroit 8
Michigan Steel Processing Co.
3120 Denton, Detroit 11
Standard Steel Treating Co.
3468 Lovett Avenue, Detroit 10
Vincent Steel Process Co.
2424 Bellevue Ave., Detroit 7
State Heat Treat, Inc.
520 32nd Street, S. E., Grand Rapids 8
Metallurgical Processing Company
2703 East Nine Mile Road, Hazel Park
American Metal Processing Co.
12000 East Nine Mile Road, Van Dyke

MINNESOTA

Metallurgical, Inc.
900 East Hennepin, Minneapolis 14

MISSOURI

Metallurgical, Inc.
1727 Manchester Ave., Kansas City 8
Lindberg Steel Treating Co.
650 East Taylor Ave., St. Louis 15
Paulo Products Co.
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Highway 25 and LaFayette St., Elizabeth
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246 Raymond Boulevard, Newark 5
L-R Heat Treating Co.
107 Vesey St., Newark 5
Temperature Processing Co., Inc.
228 River Road, North Arlington

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Alfred Heller Heat Treating Co., Inc.
391 Pearl St., New York 38
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Rochester Steel Treating Works
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OHIO

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Ferrotherm Co.
1861 E. 65th St., Cleveland 3
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Ohio Heat Treating Co.
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Metlab Company
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P. O. Box 5054, Dallas
Superior Heat Treating Co., Inc.
P. O. Box 1686, Fort Worth 1
Cook Heat Treating Co., of Texas
6233 Navigation Boulevard, Houston 11
Lone Star Heat Treating Corp.
5212 Clinton Dr., Houston 20

WISCONSIN

Allied Metal Treating Corp.
830 S. Fifth St., P. O. Box 612, Milwaukee 1
Metal Treating, Inc.
720 South 16th St., Milwaukee 4
Supreme Metal Treating Co.
4440 West Mitchell St., Milwaukee 14
Thurner Heat Treating Co.
809 West National Ave., Milwaukee 4
Wisconsin Steel Treating & Blasting Co.
1114 South 41st Street, Milwaukee 15
Harris Metals Treating Co.
4100 Douglas Ave., Racine

CANADA

B. & W. Precision Heat Treating Co.
70 Borden Ave., S., Kitchener, Ontario

INSTITUTE

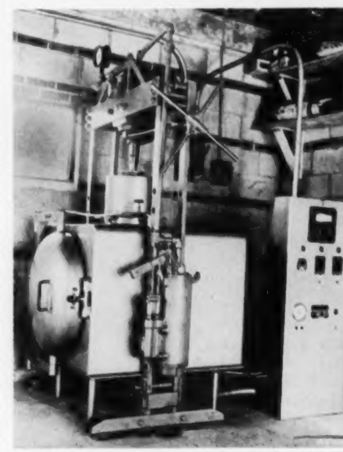
271 NORTH AVENUE
NEW ROCHELLE, NEW YORK

NEWS TO HEAT TREATERS

(*Continued from page 29*)

VACUUM FURNACE

The Lockhart Research Foundation of Gary, Indiana, engaged in research on photosynthesis using nuclide migration of radioactive materials, has installed a new type HUPPERT high temperature vacuum furnace, built in conjunction with a high pressure press developing 70 tons pressure on a 5" diameter diaphragm. This type of furnace can be designed for tempera-



tures up to 2400 degrees Fahr., and 29" of vacuum with the temperature and vacuum automatically controlled.

High temperature vacuum furnaces having heating chambers of 6 cubic inches to 27 cubic feet, with or without the high pressure press feature, are manufactured by the K. H. Huppert Co., of Chicago, Ill.

For further information circle No. 2

METALLURGICAL MICROSCOPE

A metallurgical microscope featuring many new design features has been introduced by the Bausch & Lomb Optical Co., Rochester, N. Y.

Shown is the Model DMETR equipped with Tri-vert Illuminator (jutting from side) which permits dark field, light field, and polarized light studies of metal specimens.

(*Continued on page 41*)

RIGHT OR WRONG *(Continued from page 26)*

Sam Locane was an old timer. He had 20 years seniority. The management, in an effort to cut costs, embarked on a "job re-engineering" program. As a result, Sam's job was eliminated. He was offered another job, but one at a lower rate. Sam said, "No, thanks. I'll take severance pay—20 weeks of it, according to policy." The company refused. Its position was:

1. Sam is not being displaced. He is on the payroll and has been offered another job.
2. If he refuses to take this lower job, then he is a "voluntary quit" and not entitled to severance pay.
3. The purpose of severance pay is to cushion the hardships of unemployment. Sam is not undergoing any such hardship. In fact, he is being offered work.

Was The Company: RIGHT ☐ WRONG ☐

What Arbitrator James C. Hill Ruled:

"The company contends that if Locane should reject the job at lower pay, he would have voluntarily quit. This is a possible construction. In general, severance pay is not applicable to "voluntary quits." However, most labor relations men agree that where an employee is downgraded because of technological developments, it for the employee, not the company, to make the choice between severance pay and a lower rated job. Sam Locane is entitled to that choice. He picks severance pay in lieu of downgrading. He must be paid."

When Can't You Fire An Employee For Turning Out Defective Work?

What Happened:

The foreman of the department was fed up. For over six months defective work was being turned out by several employees. Talking to the lax employees didn't seem to do any good. The supervisor took to warnings and other measures. Three employees received warning slips, and on second offense were given a week's disciplinary lay-off. All the employees knew that management was getting tough on sloppy output. One morning the foreman came in and discovered that someone on the night shift had so fouled up a job that it took two days to re-do the product. Investigation showed that this very poor job was turned out by Mrs. Drucilla Bomar. She was a relatively new worker, having been on the job a week over her probationary period. But she was no novice on the job, having had three years of previous experience. The foreman met with other members of management and they decided that things had gone far enough. An example must be made. Mrs. Bomar was fired. She balked, and when management stood its ground, the worker pressed her case to the arbitration step. She argued:

1. Yes, I made an error on the job. I'm guilty.
2. But others had made similar errors and they weren't fired.
3. My probationary period had passed, so I'm entitled to the same standards of discipline as other employees.

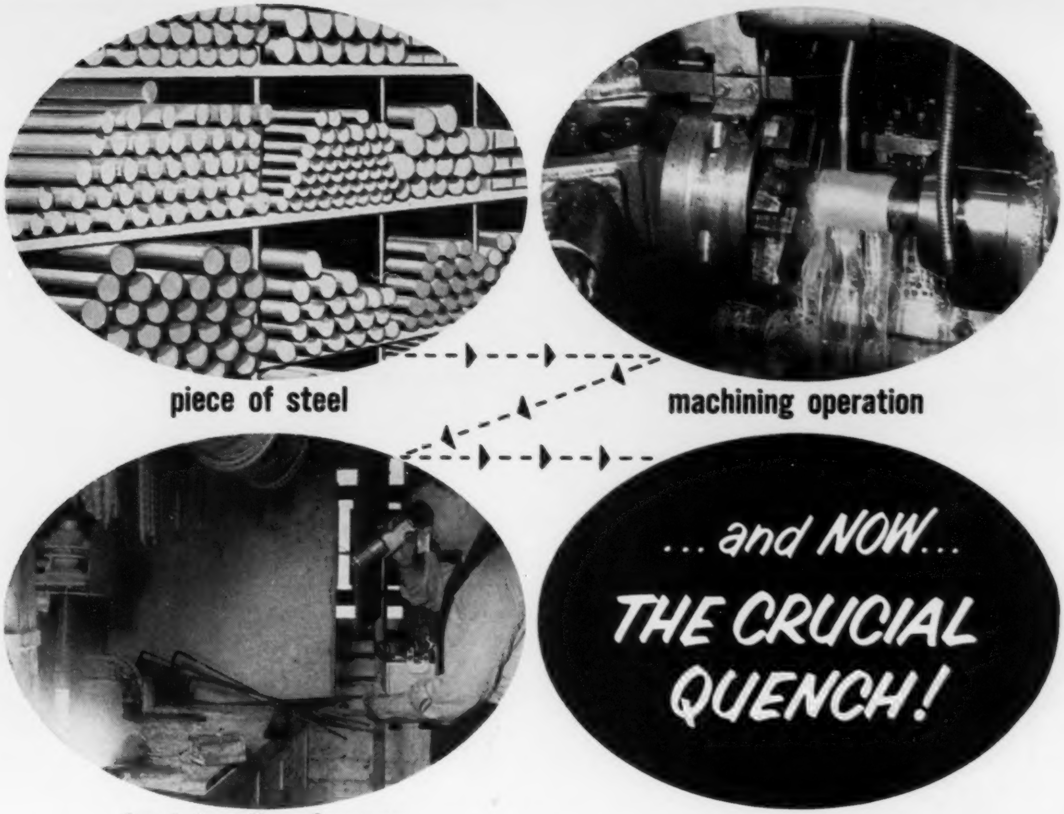
The company came back:

* We feel the offense was serious enough for discharge.
* You're a new worker and the company doesn't have the obligation it has toward old timers.
* If we don't start some drastic action to curb defective work, we may as well go out of business.

Was The Company: RIGHT ☐ WRONG ☐

What Arbitrator Whitley P. McCoy Ruled:

"There can be no question that Mrs. Bomar's offense was a serious one. Neither can there be any question that some offenses are so serious as to call for summary discharge rather than for corrective discipline. What such offenses are is a question that need not be gone into at this time, for it is clear that the company's policy has not been to treat the offense of which Mrs. Bomar was guilty as one calling for summary discharge. It should go without saying that the mere fact that considerable trouble had been caused, here in this mill or in other mills of the company, by defective splicing, does not justify a complete departure from established policy for a first offense. In view of the established policy of the company, the most severe penalty that could be justified would be a layoff without pay for two weeks. The discharge will therefore be set aside—it will be changed to a disciplinary layoff of two weeks, and Mrs. Bomar will be reimbursed all wages lost since her discharge, except for such two-week period."



The quench must be right, or the whole job is wrong

Ask any heat treater. When you come to the quench, you can't take chances. Expensive material, costly machining, painstaking heat treating can all be ruined if the quench goes wrong. All the work that went before depends upon this final step. If it "misses", the job is no good.

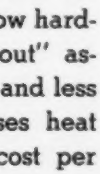
Top heat treaters don't risk costly processing on ordinary quenching oils. They know they can depend upon the uniformity, quenching speed and stability of Houghto-Quench. They know it's just common sense to use the best quenching oil you can get.

Houghto-Quench Oil gives you the fastest quench this side of water, and it's this speed that assures adequate hardness even for heavy sections and for steels in the low hardenability range. Its complete "wet-out" assures you there will be no soft spots and less carry off. Houghto-Quench increases heat treating effectiveness, with lower cost per ton of steel quenched.

Ask your Houghton Man to show you the superior performance of Houghto-Quench or write direct to E. F. Houghton & Co., 303 W. Lehigh Avenue, Philadelphia 33, Pa.

QUENCHING OILS...products of

E. F. HOUGHTON & CO.
PHILADELPHIA · CHICAGO · DETROIT · SAN FRANCISCO



Ready to give you on-the-job service ...

THE APPRENTICE CORNER

Editor's Note: *The following column appears regularly in METAL TREATING and is designed to aid young men who have only recently started in the heat treating industry. If you would like to see specific subjects discussed, or if you have any questions, let us know what they are.*

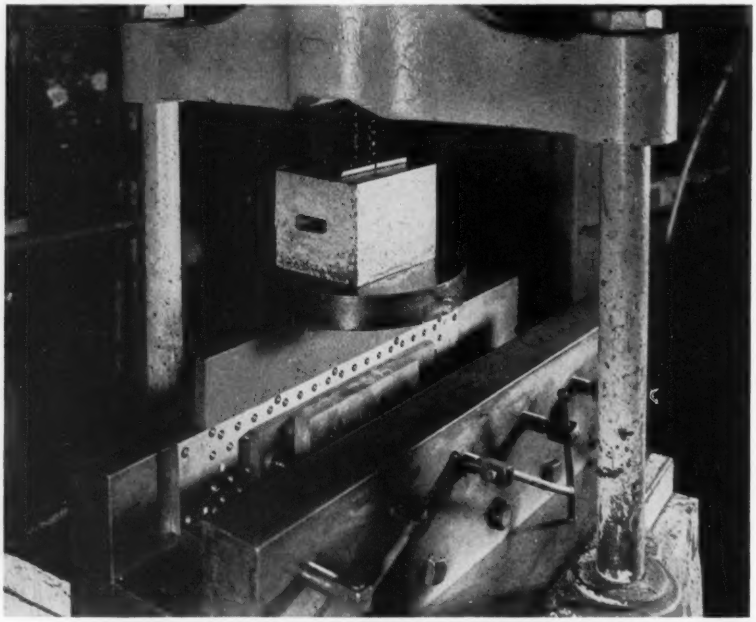


Fig. 1—Screw press with side clamp device.

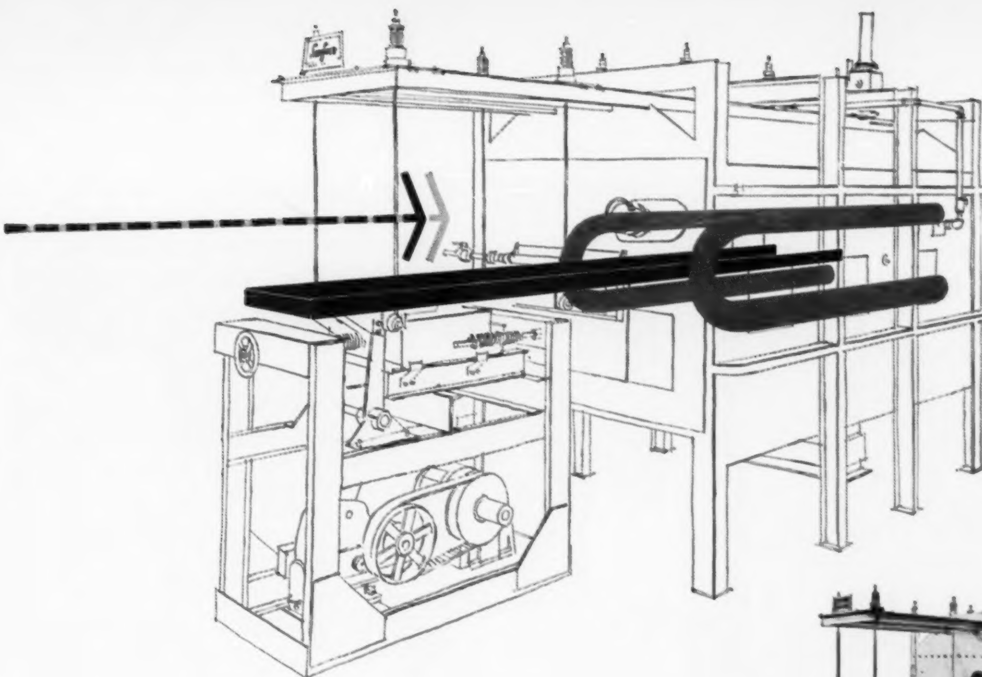
STRAIGHTENING

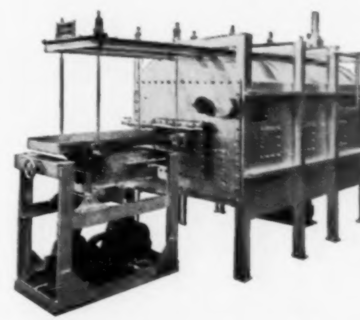
Straightening is one of the processes which makes the science of heat-treating an art. Skilled men can accomplish the almost impossible and in numerous instances save hours of grinding or machining time. Of the many methods used for straightening, the technique developed for correcting warp and distortion during the cooling period from the start of transformation to martensite to the completion of martensite transformation is undoubtedly the most important. Some highly alloyed steels will retain austenite even when at room temperatures but this is of no importance as far as this phase of straightening procedure is concerned. With the exception of jig temper straightening the other methods may generally be considered as operations not directly associated with the heating, quenching and tempering of steel. This will be elaborated in future articles.

The advantages of straightening during the martensite transformation period greatly outweigh the disadvantages of working with comparatively hot objects. Closer tolerance and less chance of rupture during straightening operations are definite factors to be considered in heat treating practice. High speed and air hardening steels are usually straightened during cooling from approximately 1100°F to 150°F. The high alloy steels and oil hardening tool steels are cooled from approximately 400°F to 150°F. The temperatures for each type of alloy steel at which straightening should begin, are dependent upon the start of martensite transformation, and to some extent on the size and shape of the part. Water hardening steels are processed in the same manner but it is more difficult to judge the temperature of the part at the time of removal from the water quenching media. High speed, oil hardening and alloy steels may be quenched either in molten salts or hot oil close to or below the starting of martensite transformation, held for the necessary time for temperature uniformity throughout the mass, removed and straightened.

A screw press and the side clamp device shown in Fig. 1 will serve for many varieties of shapes. With additional jigs and set-ups even rounds or shafts can be kept straight in the same manner as the mold plate in the illustration. The advantage of this process rests on the fact that the parts so straightened will exhibit the same hardness as that of steels quenched in the conventional oils at 150°F. with their accompanying warp and distortion. It is, of course, necessary that the parts be tempered to the required hardness. Clamping in a holding fixture will minimize distortion during the tempering cycle.

Fred Heinzelman, Jr.
Fred Heinzelman & Sons





New furnace puts "snap" in small parts production

The quantity and quality of small parts can be increased by controlled atmosphere heating and quenching in this new Surface® Snap Hearth Furnace. Production rates up to 300 lbs/hr are being attained in many plants.

This is the first suspended hearth furnace to use suction type radiant tube firing, which eliminates a muffle and its replacement problems. Another important feature is the hearth, which snaps to move the parts a short distance at regulated intervals. Hopper loading can be easily applied to the furnace.

Combined with Surface atmosphere generating equipment, the Snap Hearth Furnace is especially efficient for clean hardening, dry cyaniding, carbon restoration. In several plants, the furnace is part of completely automatic hardening-tempering lines.

Snap up your small parts production; ask your Surface man to show you how the Snap Hearth Furnace fits your plant.

Send for Bulletin SC-173. Surface Combustion Corp., 2381 Dorr St., Toledo 1, Ohio.

Surface®

HEAT TREATING EQUIPMENT

SURFACE COMBUSTION CORPORATION

Also makers of Janitrol® automatic space heating and Kathabar® humidity conditioning units

Commercial Heat Treaters to Exhibit in 1956 Metal Show

The 1956 edition of the National Metal Exposition and Congress—"the Metal Show"—to be held in Cleveland from October 8 thru the 12th, will be the largest in the 38 year history of the show.

It is reported that an exhibitor roster of 465 companies will fill every one of the 250,000 square feet available in the city's huge Public Auditorium and Exhibition Halls. Members of the Institute who will be among the exhibitors are The Lakeside Steel Improvement Co., Cleveland, Ohio, and Metallurgical, Inc., Minneapolis, Minn. They will be exhibiting various products that have been commercially heat treated as well as some of the equipment used in heat treating thus spotlighting the skills and facilities of the commercial heat treater.

Cleveland is one of three cities whose facilities provide adequately for the Show, theme of which for this year is "Spend-to-Save."

Advance estimates indicate attendance at the upcoming Cleveland Show will be close to 46,000. Registration falls into three classes—members of the American Society for Metals and of associated societies, guests invited by exhibitors, and the general industrial public which may register and for only a $1.00 fee, gain admittance.

Metal Show officials report growing plans by industry to organize "buying teams" whose responsibility is to cover the huge show to assure that no product innovation bearing on operating improvements is missed.

Bank Publicizes Member

The Chestnut Hill Branch of the Philadelphia Trust Company, Philadelphia, Pa. invited local industries in the Chestnut Hill area to set up an exhibit booth in its lobby in order to illustrate their plants and products. A member of the Institute, the Metlab Co., Philadelphia, Pa., was invited to participate, and a picture of their exhibit is shown here.

Because of the space limitations of the booth in the lobby of the bank, only small articles processed by Metlab could be shown.

Traveling Member

Mr. and Mrs. Fred Heinzelman, Sr. spent the summer on an extended tour of Europe—visiting old friends and business acquaintances and relatives.

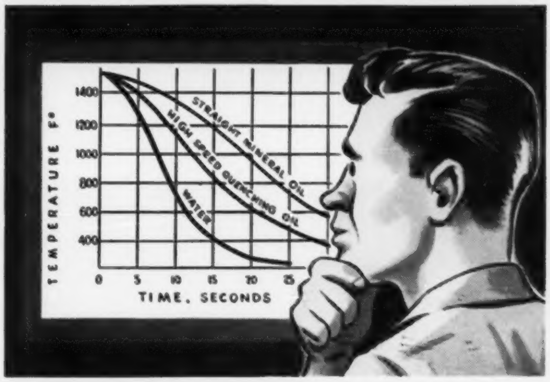
They had an interesting visit and discussion with Mr. Werner A. Stauffer, Chief Metallurgist of the Esher Weiss Company. Mr. Stauffer is a noted author of papers and articles on the subject of the heat treatment of metals, and the company is a leading manufacturer of electric motors, turbines, ordnance, and large industrial equipment.

Member Is a Successful Big Game Hunter

C. Robert Derhammer, secretary, metallurgical engineer and purchasing agent at the Lakeside Steel Improvement Co., Cleveland, is one of the few members of the Cleveland Association that has ever shot a 400-lb. black bear.

Bob set out a few weeks ago with some fellow members of the Al Koran Hunter's Camp of Cleveland to bag four trophy black bears and obtain an official mascot. Through the aid of the Ontario Department of Lands and Forests the mission was successful.

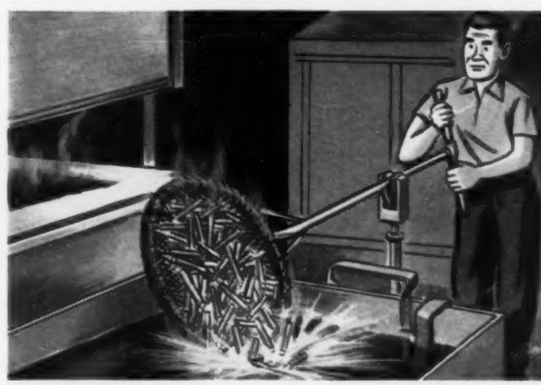
The group drove 800 miles to Kirkland in Northern Ontario, Canada, where the land is available for fifty cents an acre. One



1. Quenching Speed. There are two basic types of quenching oils...straight mineral oils and compounded high-speed oils. If you can get the microstructure and hardness you need and have no distortion problems with a straight mineral oil, then it's the type to use. If you're not getting the results you want, increased agitation may help. If increased agitation doesn't help, or isn't practical, you should use a high-speed oil.

2. Naphthenic vs. Paraffinic. Both types of oil are used for quenching. Both have their own inherent advantages. Naphthenic oils keep oil coolers cleaner when the temperature of the oil doesn't exceed 150 F. A fully dewaxed paraffinic oil gives the most satisfactory results at temperatures over 150 F. As a rule, when all other operating factors are equal, the temperature of your oil bath tells you which type of oil to use.

What's the difference in quenching oils?



3. Thermal Stability. This is the biggest single factor influencing the useful life of a quenching oil. The higher the temperature of the oil bath, the shorter the life of any given oil. As mentioned before, at temperatures over 150 F it takes a stable, fully dewaxed paraffinic oil to give the most satisfactory results. For maximum useful life at temperatures over 200 F you will probably need a specially inhibited quenching oil.

4. Other Considerations. When quenching from a salt pot, use a straight mineral oil. Don't use an oil containing lard oil or other vegetable or animal fats. The salt carried into the oil on the parts will cause these fats to saponify and form oil-thickening grease. For bright quenching, experience shows that a straight mineral oil will give the best over-all results. For the most part, a straight oil will give cleaner parts longer.

These facts are nothing more than a guide to help you select the quenching oil best suited to your particular needs. To arrive at the final answer, there's no substitute for experience. Sun's representatives, backed up by Sun's metallurgical staff, have that experience. And, they're backed up by a *complete* line of quenching oils, paraffinic or naphthenic, regular or high-speed, straight or inhibited. Sun makes them all. For more information, see your Sun representative or write Sun Oil Company, Philadelphia 3, Pa., Dept. MR-9.

INDUSTRIAL PRODUCTS DEPARTMENT

SUN OIL COMPANY

PHILADELPHIA 3, PA. ©SUN OIL CO.

IN CANADA: SUN OIL COMPANY LIMITED, TORONTO and MONTREAL

SUNOCO

hundred miles north of Tamagamy was the locale for this wildlife hunt. The group (divided into two sections) spotted eleven bears and were lucky to get four of them plus the cub, which they later adopted as a mascot.

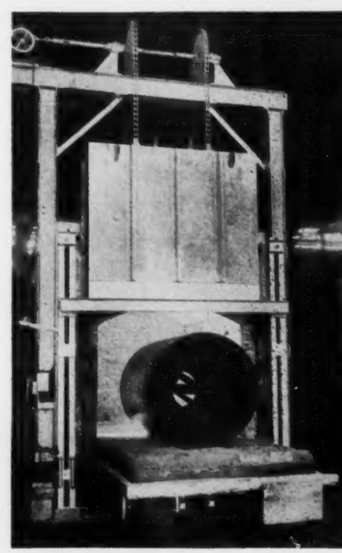
Upper left shows C. Robert Derhammer, Lakeside Steel Improvement Co., Cleveland, holding the skin from a 400-lb. black bear that he bagged recently in upper Canada, during a hunter's safari of the Al Koran Hunter's Camp of Cleveland. Elmer Davis of Davis Tool Co. is pictured on the right with the skin of the bear he shot. Lee Birch holds a black cub, which is now the official mascot of the Cleveland group of Al Koran hunters.

A Marlin lever-35-Remington caliber gun operated by Derhammer brought down the 400-pounder after three well-placed shots. It was getting dark when the bear suddenly surprised Derhammer in the brush. Quick action brought the animal to his death.

Elmer Davis, who heads Davis Tool Co., in addition to shooting an adult bear, also enticed the cub bear to leave its habitat. It was then added to the entourage and taken back home.

Bob's bear is being fully mounted and will be on display at the coming Metal Show at their booth, No. 306. After the Show, the bear will be hung in the purchasing office at Lakeside Steel Improvement.

Member's New Equipment



Benedict-Miller's new car furnace.

The latest addition to the heat treating facilities of Benedict-Miller, Inc., Lyndhurst, New Jersey, is a car furnace for annealing and stress relieving, and is shown here in the photograph. The inside dimensions of the furnace are 6 feet wide; 11 feet long; and 5 feet 6 inches high. ■ ■ ■

NEWS TO HEAT TREATERS
(*Continued from page 32*)

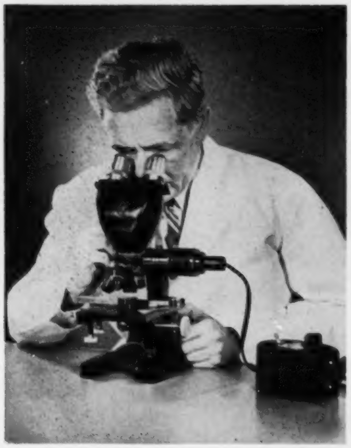
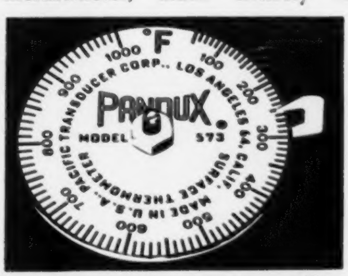


Photo also illustrates the new low-level fine-focus knob (shown in the user's left hand) which permits rapid focusing. The knob for setting the new adjustable stage is located alongside the fine-focus knob.

For further information circle No. 3

SURFACE THERMOMETER

Pacific Transducer Corp., Los Angeles, California, has announced a new Spot Check Surface Thermometer. This is a new type of thermometer, made entirely of



stainless steel, with a range of from 50°F. to 1000°F. It is said to be easy to read, compact and very fast-operating. Merely lay the instrument on the surface to be checked—within 60 seconds the thermometer will reach stability, and exact temperature can be easily read. It reads accurately temperatures of all surfaces, such as dies, hot plates, heavy
(*Continued on page 44*)

HEAT TREATMENT OF STEEL *(Continued from page 16)*

different from pearlite formed above 1000°F., and this structure, called bainite, is shown in Fig. 7. The degree of fineness of the bainite structure increases as the temperature of formation is lowered from 1000°F. It is generally thought the pearlite is nucleated by cementite and bainite by ferrite.

As the temperature of the quenching bath is lowered, a temperature level is reached where austenite will undergo some transformation instantaneously on reaching that temperature, a period of inactivity when held at that temperature, followed by further decomposition to bainite for longer holding times. The microstructure formed immediately on reaching this temperature is martensite. Martensite will continue to form instantaneously as the temperature is lowered but will not form isothermally. The temperature at which the first martensite is formed is termed the M_s temperature, and the temperature for 100% martensite formation is called the M_f temperature. The M_s temperature depends upon the composition of the steel and can be estimated from the following formula:

$$M_s\ (^\circ F.) = 1000 - (650 \times \%\ C) - (70 \times \%\ Mn - (35 \times \%\ Ni) - (70 \times \%\ Cr) - (50 \times \%\ Mo)$$

The M_f temperature cannot be calculated from the composition of the steel.

The transformation of austenite to martensite does not depend upon nucleation and diffusion, as is the case for pearlite and bainite formation, but solely on reaching a temperature level where the face-centered cubic lattice tends to transform to a more stable type of lattice. The lattice formed is a tatragonal body-centered type with the carbon atoms trapped as an atomic dispersion in the interstices of this lattice.

The primary purpose of quenching a steel is to produce martensite. Therefore it can be seen that it is necessary to employ fast enough cooling rates to prevent the steel from dwelling in the higher temperature ranges where ferrite, pearlite, and bainite will form. Alloying elements shift the T-T-T diagrams to the right, i.e. longer times for the beginning of transformation, which permit slower rates of cooling for the formation of 100% martensite. ■ ■ ■

HEAT TREATING HINTS

Remedy for Short Circuiting

Troublesome failures of the rod overbend electric heating elements short circuiting in various carbonitriding furnaces in which the elements are exposed to the gaseous atmosphere can be avoided. Because of the proximity of the elements, the carbon build-up between them during the carburizing and carbonitriding cycles is fairly rapid. (Fig. 1). This in turn will cause the current to jump the gaps between the elements.

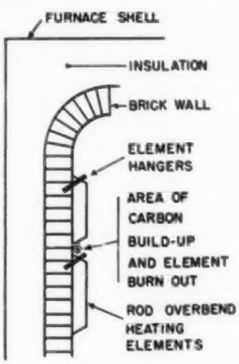


Fig. 1

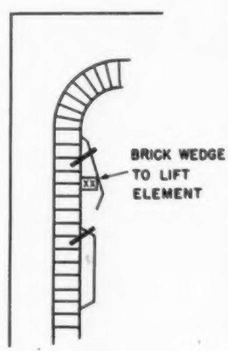


Fig. 2

The remedy is a simple one (Fig. 2); insert a brick wedge which will lift the heating element away from the wall and increase the space between them. Current no longer can jump the gap, and carbon deposit is reduced.

Previous to our devising this remedy, the failures occurred as often as three times a month on a twenty-four hour work schedule. Purging the furnace and blowing out the deposited carbon with air every eight hours did not aid in reducing the failures. Since the rod overbend elements have been readjusted as shown in Fig. 2, purging is now needed only every twelve hours and the furnace has continued to produce for more than seven months under identical work load conditions without element repairs. ■ ■ ■

Carl Heinzelman,
Fred Heinzelman & Sons

Editor's Note: *If you have any items of interest, please send them along.*

NEWS TO HEAT TREATERS

(Continued from page 41)

sheet metal, furnace skins, boilers, large super-heated steam pipes; cooled billets, etc. Besides the surface temperatures, it also reads ambient temperatures in furnaces, ovens and other enclosed spaces; as well as in non-corrosive liquids and gases, up to 1000°F.

The thermometer comes accurately calibrated to within plus or minues two per cent, and can be reset by the user, if necessary, at any time. The diameter is $1\frac{3}{4}''$ overall, and the weight is 1/3 oz.

For further information circle No. 4

HEAT TREATING FURNACES

The R-S Furnace Company, Incorporated, Philadelphia, Pennsylvania, has been awarded a contract to build two Aluminum Plate Solution Heat Treating Furnaces for the Davenport Works of the Aluminum Company of America under a prime contract with the U. S. Air Force.

The furnaces are said to be the largest of their kind in the world and are expected to go into operation late in 1956.

INDUSTRIAL HEATING EQUIPMENT SALES

Figures released by the Industrial Heating Equipment Association, whose member companies make industrial furnaces, combustion equipment and induction and dielectric heating equipment, show that orders received for industrial furnaces for June, 1956, are up 142% over orders received for June, 1955, which was, itself a record year.

(Continued on page 46)

LETTERS TO THE EDITOR

Dear Editor:

We acknowledge receipt of your letter regarding tear sheets of Case's article, "A Review of Salt Bath Carburizing" that was published in the May-June and July-August issues of METAL TREATING.

We have received reprints of this article from the American Cyanamid Co. to whom you had referred our request.

Thank you for your cooperation in this request.

J. K. LERCH
Librarian
Metallurgical Department
The Carpenter Steel Company
Reading, Penna.

Ed.—Companies who order reprints of articles published in METAL TREATING are always glad to fill requests for copies of these reprints.

Dear Sir:

First let me say that I much appreciate having my name added to your mailing list to receive METAL TREATING. I have received the May-June issue and I find it most interesting.

I was most impressed and pleased with the completeness of the information which you sent in regard to the Institute. I rather feel that our position as a supplier of metals for the Institute does not make us eligible to join the organization. I should like to add, though, that judging from the information which you sent and from comments given by heat treaters in this area, you have an excellent organization doing a fine service in your field. Our congratulations to you in this respect.

C. N. DETRICK
Williams and Company, Inc.
Cleveland, Ohio

Ed.—The Metal Treating Institute and the magazine appreciate the kind words.

Dear Editor:

Last week I was given a copy of your heat treating magazine, METAL TREATING.

I found it a very helpful and interesting book. Would you please put me on your mailing list for your future issues, it would be very much appreciated.

JOHN W. HALL
Heat Treat Foreman
Schaeffer's Tool and Die Division of
W. A. Schaeffer Pen Company

Ed.—He too, is obviously qualified and eligible, and his name has been gladly added to our mailing list.

Dear Editor:

One of my American friends, Mr. Archer, president of the California Doran Heat-Treating Company has brought my attention to your paper METAL TREATING, and has been kind enough to show me one or two copies.

Being president of one of the leading Danish commercial heat-treatment plants, I must say that I found your paper very interesting and am very anxious not to miss one single issue, so I hope that you would be kind enough to send me your subscription rates as well as information with regard to the Metal Treating Institute.

Does the Metal Treating Institute issue other publications on heat-treatment?

I am anxiously looking forward to your information.

PEER SVENDSEN, President
Uddeholm
Copenhagen, Denmark

Ed.—A foreign subscription application was sent as well as some copies of the reprints of articles from METAL TREATING which the Institute distributes.

Dear Editor:

We are extremely interested in METAL TREATING and have noted with a great deal of interest, your editorials, as well as diversified advertising features.

Since we are seriously considering the possibility of extended ad-

vertising during the coming year, we would be pleased to have you place our name on your mailing list for all future publications.

Any expenses in connection with this matter will be honored upon receipt of your billing.

F. W. FAERY
Frank W. Faery Company
Detroit, Mich.

Ed.—This qualified subscriber has been added to the mailing list, and we hope we may be of further service to him.

Dear Editor:

Would you please put me on your mailing list. Have read your METAL TREATING and find it to be just what we need around here.

STEPHEN KOLAREVIC
Tool Room Heat Treater
Detroit Transmission Division
General Motors Corporation
Ypsilanti, Mich.

Ed.—Mr. Kolarevic obviously qualifies to receive METAL TREATING as a heat treater in a heat treating department of a manufacturing plant and his name has been added to the list. Glad the magazine is so helpful.

Dear Editor:

I have been enjoying reading your magazine since I came to Pittsburgh, Pa. last summer. I am very grateful for your generosity in sending me a copy of it every issue. I don't think I ever came across such an interesting publication in this field.

May I ask you for a favor in continuing to send me a copy bimonthly, as I am going back home to Japan this summer. Would you please tell me how much I have to pay annually to you as handling charge. I will send it to you before I leave.

Incidentally, my company, Daido Steel Co., Ltd. is the largest alloy steel maker in Japan as well as a builder of industrial furnaces.

AKIRA NAKAOKA
Engineer
Daido Steel Co., Ltd.
Nagoya, Japan

Ed.—An arrangement was made to have his subscription transferred to Japan, and an additional paid foreign subscription was sent in from Japan by his employer, Dr. Tatsuo Hayashi.

NEWS TO HEAT TREATERS

(Continued from page 44)

The comparable figures are $25,597,087 for June, 1956, as against $10,616,234 for 1955.

For the first six months of 1956, industrial furnace orders received equal $67,452,569, the Association said. This compares with $42,393,613 for the first six months of last year—an increase of 59%.

Translations Available

Aware that much good literature of value and interest to heat treaters is being published abroad, METAL TREATING has made arrangements with a professional translator to advise us regularly of the availability of English translations of outstanding magazine articles, books, texts, etc., that would be of value to heat treaters. We shall publish such a list in this column in each issue.

The following translations are

(Continued on page 52)

MANUFACTURERS' LITERATURE

For your copy circle the number on the Readers' Service Card

HIGH FREQUENCY CAPACITORS

High-frequency Pyranol® capacitors, generally designed for power-factor improvement in circuits operating at frequencies from 500 to 12,000 cycles per second, are described in a new four-page bulletin now available from the General Electric Company, Schenectady 5, N. Y.

The majority of applications of the high frequency capacitors are with induction heating equipment for melting, forging, heat treating and hardening operations.

For further information circle No. 5

CATALOG ON CLEANING PROBLEMS

The application of specially designed airless blast equipment to 56 production cleaning problems, such as those encountered with cast, welded, forged, heat treated, and machined components used in automotive, railroad, ordnance, farm, and all sorts of other equipment and machinery is fully described in a 34-page brochure published by Wheelabrator Corporation, Mishawaka, Indiana. This profusely illustrated booklet includes the following other categories of cleaning and finishing in its large collection: descaling of hot rolled steel strip, sheet, slabs, billets, and structural steel; etching steel mill rolls; cleaning tubing, soil pipe, steel drums, sanitary ware, and many other items. The shot peening process is also treated.

Descriptive drawings accompany the photographs. Performance figures are given for specific cases.

For further information circle No. 6

NEUTRALENE GAS PRODUCERS

An 8-page bulletin published by General Electric Company, Schenectady, N. Y., gives pricing data, product features, dimensions, and application data on General Electric Neutralene gas producers which produce purified exothermic gas for protective atmosphere heat treating.

For further information circle No. 7

MARTEMPERING WELDMENTS

Martempering of long steel aircraft weldments with negligible distortion, no quench cracks, and minimum decarburization, by Rohr Aircraft Corporation, Chula Vista, California, is described in a new bulletin published by the Ajax Electric Company, Philadelphia, Pa.

For further information circle No. 8

DUST COLLECTOR

The new Ventrijet made by the Pangborn Corporation, Hagerstown, Md., for the wet collection of industrial dusts is illustrated and described in a new 8-page brochure.

Fifteen photographs and drawings show the unique action of the Ventrijet. Dimensions, weights and capacities are presented in three tables.

In the Ventrijet, utilizing the venturi tube principle, water is broken into fine particles and mixed with dust-laden air without mechanical means in one or more venturi tubes. Dust entrapped in the water particles settles to the bottom of a tank built integrally with the collector for automatic, mechanical removal.

For further information Circle No. 9

"HEAT TREAT REVIEW"

The 8-page, illustrated house organ of Surface Combustion Corp., Toledo, Ohio, contains an article on the solution of a variety of heat treat problems in a southern California commercial heat treat shop.

Other stories tell about the improvement of heat treat results with modern gas chemistry and how a team of furnaces produces higher-quality parts in an aluminum fabricating plant.

For further information circle No. 10

HEAT TREATING CASTINGS

Michigan-Standard Alloy Casting Co., Detroit 7, Mich., has recently published a 16-page illustrated manual on heat and corrosion resisting castings.

To users of such castings, Michigan-Standard has made this manual available as a source of general information on the principles of alloy composition, their properties and limitations, stabilizing influences and heat treatment, etc.

Use of this comprehensive manual can be of much value in determining the type of heat and corrosion resisting metals to be considered when selecting castings for industrial applications which are subject to high temperature or chemical corrosion.

For further information circle No. 11

HIGH CONVECTION ANNEALING

A 6-page bulletin giving operational views and describing the features of the Lee Wilson High Convection Annealing System for non-ferrous metals has been recently published by the Lee Wilson Engineering Co., Cleveland, Ohio.

Included are descriptions of the new "O" type radiant tube with inputs up to 5 million Btu. per hour and a specially developed Plenum Chamber that increases the efficiency of the gas flow over the charge.

The bulletin also gives some detail of the Lee Wilson Diffuser Assembly, a new Forced Cooler, and new design Convector plates.

For further information circle No. 12

ULTRASONIC SYSTEMS AND APPLICATIONS

The benefits which may be derived from ultrasonic techniques in cleaning and degreasing, electroplating, drilling and grinding operations are reported in a new bulletin published by Acoustica Associates, Inc., Glenwood Landing, L. I., New York.

Entitled, "Ultrasonic Barrier Broken by Low Cost Power Supply", the 4-page, 2-color bulletin also describes various ultrasonic power supplies, transducers, and systems offered by Acoustica for small and large scale production requirements.

For further information circle No. 13

PHOTOGRAPHIC PROCESSING

The JAco "Photoprocessor" provides—in one compact, self-contained unit—all facilities needed for uniform developing, fixing, washing and drying of both films and plates.

For use in spectrochemical laboratories, the JAco "Photoprocessor" may also be used to advantage in X-ray diffraction laboratories, metallographic laboratories, and for processing of photomicrographs.

For further information circle No. 14

ENDOTHERMIC GAS PRODUCERS

Thermalene Gas Producers — a new publication of four pages, gives application data, product descriptions, dimensions, ratings, and diagrams of General Electric Thermalene (Reg.) (endothermic) gas producers for production of protective atmosphere gases for heat treating. Also included is operating data giving approximate gas costs based on materials consumed at rated output.

For further information circle No. 15

INDUSTRIAL ELECTRIC HEATING BULLETINS

C. I. Hayes, Inc., Cranston, Rhode Island, has just published 4 new bulletins dealing with the various equipment which they manufacture for the heat treating industry.

One bulletin describes the unique Hayes Laboratory and its services; another deals with their atmosphere equipment; another describes and illustrates their pusher furnaces; and the fourth is concerned with tool hardening or preheat furnaces.

For further information circle No. 16

ELECTRIC HEATING ELEMENTS

A new 8-page brochure giving several case histories of the application of Norton "Hot Rod" Crystolon Heating Elements has been published by Norton Company of Worcester, Mass.

For further information circle No. 17

PYROMETERS

Pyrometers and resistance thermometers are described in a 2-page bulletin which describes features, accessories, application, specifications and special calibration of instruments for temperature indication and control of industrial processes. It is published by the General Electric Company, Schenectady, N. Y.

For further information circle No. 18

QUENCHING OIL

A new fast quenching oil is the subject of a Sun Oil Company's technical bulletin. This bulletin explains the mechanism of quenching, and tells how the new oil gives deeper and greater hardening of low-alloy steels and reduced distortion of irregularly shaped parts.

For further information circle No. 19

(Continued on page 57)

. . . BETTER TALK IT OVER WITH

LINDBERG

The safest way to be sure that you have the right answer for any application of heat to industry is to talk it over with the most widely experienced experts you can find. We believe we have them here at Lindberg. Our business is concerned only with the development of industrial heating equipment and we manufacture the most complete line in the field; heat treating furnaces, melting furnaces, high-frequency induction units, ceramic kilns; big ones, small ones, electric or fuel-fired, built in our plant or field-erected. Before you decide on any application of heat to industry, it's reassuring to know you have the right answer. Talk it over with Lindberg.

Melting Furnaces | Laboratory Furnaces | Field-Erected Furnaces | Carbonitriding Furnaces | Induction Heating Units

Here are some specific advantages you get only when you come to Lindberg:

- An organization of experts concentrating only on the development of industrial heating equipment.
- The most *complete* line of equipment insuring the recommendation of exactly the right methods for your specific product requirements and production processes.
- Research and development laboratories which have originated and perfected many important heating methods and processes. Among these are the Cyclone tempering furnace, automatic control of carbon potential in furnace atmosphere . . . 60 cycle induction melting . . . completely automatic ceramic kilns . . . the "Iron Lung" for treating stainless steel . . . vertical replaceable radiant tubes . . . CORRTHERM electric heating elements and many other innovations in the industrial heating field.
- A design committee of the country's top furnace and process engineers which, in cooperation with many of our good customers, has been responsible for such important developments as the high frequency method of heat treating automotive valves, rotary furnaces for forging and annealing titanium, reverbatory furnaces for aluminum and the automatic carbonitriding furnace universally recognized as the leader in the field.
- A world-wide organization of subsidiary companies, making available to Lindberg the latest developments in heat applications in foreign industry.
- A group of technically-trained Field Representatives located in fifteen industrial centers in the United States. There's a trained Lindberg man just as close as your telephone.

You can't afford not to get the best advice possible on your industrial heating problems. We are confident our experience can be helpful to you. Why not talk it over with Lindberg?

LINDBERG ENGINEERING COMPANY

2466 West Hubbard Street, Chicago 12, Illinois

Los Angeles Plant: 11937 S. Regentview Ave., at Downey, Calif.

Associate Companies: **Lindberg Industrial Corporation, Chicago • EFCO-Lindberg, Ltd., Montreal, Canada • Lindberg Italiana, Milan, Italy • The Electric Furnace Company, Ltd., Weybridge, Surrey, England • Etablissements Jean Aubé, Paris, France • Lindberg Industrie Ofenbau, Gross Auheim, Germany • Toyo Menka, Tokyo • Lindberg Engineering Company (Australia) Pty. Ltd., Melbourne**

NEWS TO HEAT TREATERS

(Continued from page 46)

available from Henry Brutcher, P. O. Box 157, Altadena, California; all are illustrated and all have bibliographies. They may be secured by ordering directly from Mr. Brutcher.

No. 2031—*Sub-zero Treating of Cutting Tools;* by I. N. Laguntsov and B. Ya. Bashkirov, translated from *Vestnik Mashinostroeniya*, vol. 27, 1947 ($2.95)

No. 3030—*Definitions of Heat Treating Processes;* by P. Riebensahm, translated from *Haerterei-Technische Mitteilungen*, vol. 4, 1949 ($5.90)

No. 409—*Isothermal Transformation of Austenite in Alloy Steels and Mechanical Properties Produced Thereby;* by I. Kontorovich, translated from *Kachestvennaya Stal*, vol. 4, 1936 ($3.50)

No. 623—*Influence of Subzero Temperatures upon Cr-W-V Steels in As-quenched State;* by N. Minkevich and others, translated from *(Kharkov) Stal*, vol. 8, 1938 ($2.90)

No. 630—*Influence of Rate of Cooling upon Transformation and Properties of Vanadium Steels;* by F. Wever and A. Rose, translated from *Mitteilungen K.-W. Institut Eisenforschung*, vol. 20, 1938 ($1.50)

No. 738—*Influence of Rate of Cooling upon Transformation and Properties of Chromium Steels;* by A. Rose and W. Fischer, translated from *Mitteilungen K.-W. Institut Eisenforschung*, vol. 21, 1939 ($1.25)

No. 1080—*Heat Treating of Large Stainless Steel Castings;* by V. Smirnov, translated from *Metallurg*, vol. 15, 1940 ($1.45)

No. 3503—*Suitable Heating and Holding Times in Commercial Heat Treating of Steel;* by W. Hulsbruch, translated from *Stahl Und Eisen*, vol. 71, 1951 ($13.20)

No. 215—*Development of Cracks in Steel During Heat Treating;* by E. Scheil, translated from

(Continued on page 54)

REPORT ON TITANIUM

(Continued from page 12)

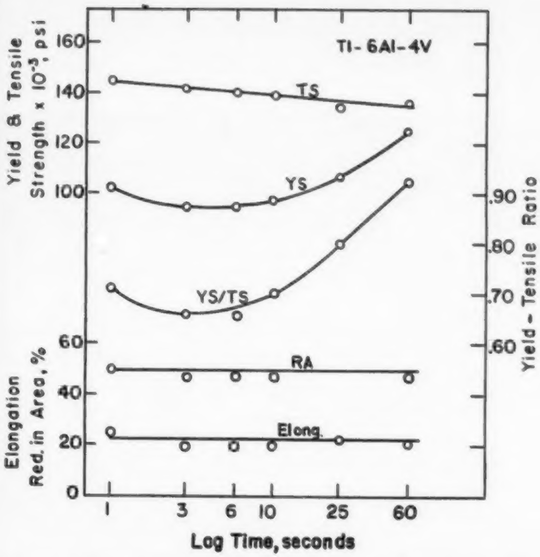


Fig. 6—Effect of delayed water quench from 1550°F. ***Data from Titanium Metals Corp. of America.***

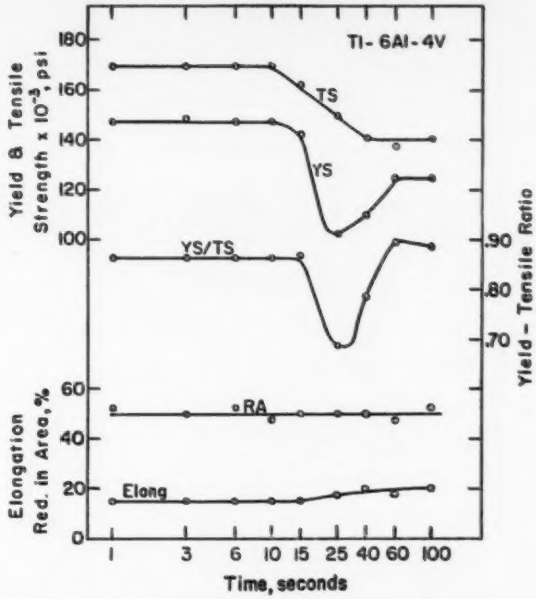
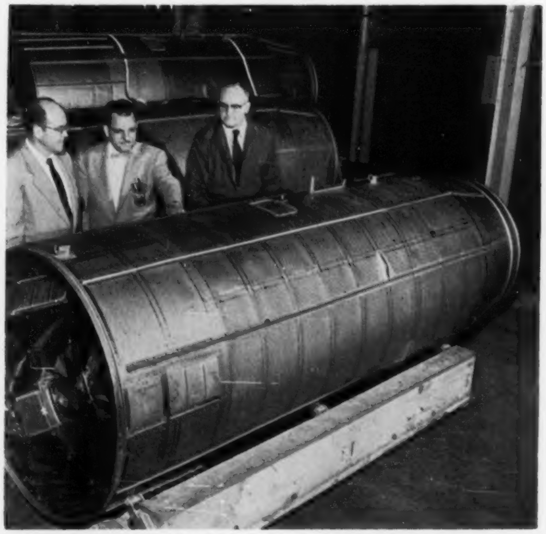


Fig. 7—Effect of delayed water quench from 1750°F. ***Data from Titanium Metals Corp. of America.***

stretched beyond its tension yield, as illustrated by Fig. 5 for the 8Mn alloy. These losses are now being restored in all commercially-used forms of titanium at Convair by heating parts at 900° to 1025°F. (±25°F.) for 20 minutes to an hour—during which fixtures are used to prevent distortion.

Limited tests conducted by Convair with titanium stretched at 1025°F. have shown that hot stretching can save money by minimizing the need for fixtures



A new type of titanium shroud for the F-102A Air Force jet interceptor is shown here at Convair Division of General Dynamics Corporation's Plant II at San Diego, Calif. Dimpling of the entire surface makes the shroud—a protective "jacket" that insulates the J-57 turbojet engine from the F-102A's fuselage—lighter in weight and at the same time stronger and more rigid than when smooth sheet titanium was used to fabricate the shrouds (background).

and heating ovens, since there was a maximum loss of 5% in compression yield of the investigated parts—and that, of course, can be restored simply by aging heat treated materials.

Despite its shallow hardening, the 6Al-4V alloy can be used to advantage because many aircraft structural members are 1" or less in cross section. However, other titanium alloys should be more practical for most applications. For example, RS-140X and 4Mn-4Al materials have deep and uniform hardening characteristics in sections up to about 4¼".

Since ovens of the types used in processing steel and aluminum can be employed, the production heat treatment of titanium should not impose undue hardship on any shop. However, careful attention must be given to delay in water quench.

As shown in Fig. 6, a delay of more than 10 seconds will reduce the yield/ultimate ratio while a three to six second delay will facilitate forming with the 1550°F. solution treatment. Similarly, Fig. 7 shows that 10 seconds is maximum delay in quench for the 1750°F. treatment; and, in this connection, it should be noted that no production advantage can be taken of the dip in curves for lower yield/ultimate ratio without incurring a sacrifice of strength.

In conclusion, it should be pointed out that titanium is not a material which will solve all structural problems. But it has a solid position in the 600°-700°F. temperature range; should, with alloys now being developed, push its frontier to 800°F.; and may well reach an even higher plateau in the near future. Proper development of heat treating techniques and the inherent heat treatability of the alloys will contribute greatly to further progress. ■ ■ ■

NEWS TO HEAT TREATERS

(*Continued from page 52*)

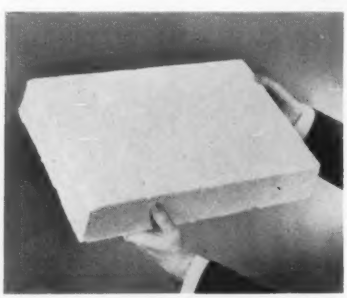
Archiv Eisenhuttenwesen, vol. 8, 1934-35 ($4.90)

No. 1864—*Influence of Austenitizing Temperature upon Ar Points of Alloy Constructional Steels;* by A. Legat and E. Plöckinger, translated from *Berg-Und Huttenmannische Monatshefte,* vol. 90, 1942 ($6.15)

INSULATION BLOCK

A new high heat resistant, lightweight, bonded Fiberfrax ceramic fiber block with improved handling and compressive strength features for high temperature insulation has been developed by The Carborundum Company, Niagara Falls, N. Y. Resistant to temperatures up to 2300°F. and chemically inert, the new F-20 Fiberfrax blocks withstand flame impingement and are unaffected by furnace atmospheres.

The new Fiberfrax block has an approximate density of 20 lbs. per cu. ft., which is about seven pounds more than Carborundum's original F-13 block. Thermal conductivity of the new block is 1.27BTU/hr., sq. ft. and °F/in. of thickness at a mean temperature of 1000°F; at 2000°F. it is 2.24. An important benefit of the low thermal conductivity is a reduction in heat capacity making furnace equipment more responsive.



For further information circle No. 20

NEW CHIEF METALLURGIST

George E. Brumbach has been appointed chief metallurgist of The Carpenter Steel Company, Reading, Pa.

He has held the position of metallurgist at Carpenter since July 1951, and now occupies an office that was vacated in July 1954 by Dr. Carl B. Post, vice president and technical director.

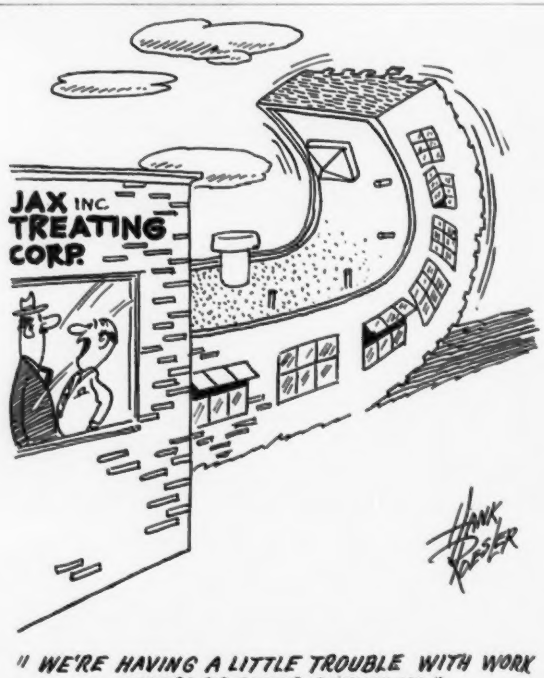
Brumbach has extensive experience in steel mill metallurgical control and inspection. He has been associated with the Carpenter Metallurgical and Research Department since his graduation from Lehigh University in 1933.

Brumbach is an active member of the American Society for Metals, and was former chairman of the Lehigh Valley Chapter in 1942-43. He has contributed a number of articles on tool steels and their heat treatment to various trade publications in the field of metalworking, including the last three issues of METAL TREATING in the department entitled "The Apprentice Corner."

FIRE TRUCK

A new pint-size fire truck for fighting fires inside industrial plants and which is capable of negotiating narrow factory aisles, was developed by Ansul Chemical Co., Marinette, Wis. It fills a need, by industry, for fire-fighting equipment with a knock-out punch.

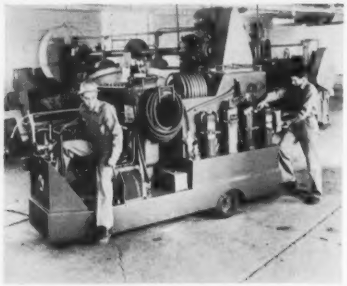
(*Continued on page 56*)



"WE'RE HAVING A LITTLE TROUBLE WITH WORK WARPAGE AFTER QUENCHING."

NEWS TO HEAT TREATERS

(Continued from page 56)



The truck can go anywhere an ordinary plant lift truck can go. It is only 5 feet, 8 inches high, giving the driver a good view in every direction.

Dry chemical, carbon dioxide and water are provided as extinguishing agents, according to the plant's need. The truck can carry many other fire fighting tools, too. Available accessories include ladders, utility bar, light, hose, portable fire extinguishers and extra nozzles, all mounted with panic-proof quick release brackets. There is storage room on the truck for fire blankets, boots, air masks, coats and a first aid kit. A flashing red light can be mounted on top of the cabinet.

For further information circle No. 21

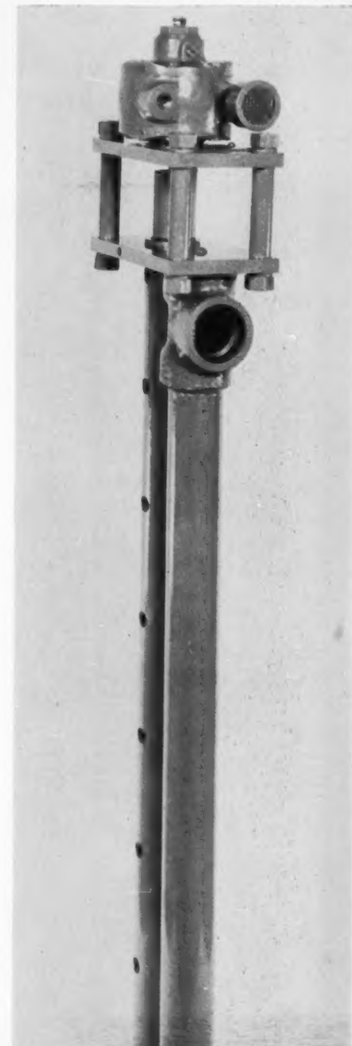
LINDBERG ADMINISTRATOR

Lindberg Engineering Company of Chicago has announced that

Richard Schoenfeld, formerly of the Hevi Duty Electric Company, later Vice President of Wheelco Instruments Company, and more recently manager of the Wheelco Division of Barber Colman Company, has joined the Lindberg organization as Administrative Assistant. Mr. Schoenfeld is temporarily taking over the reorganization of the Cleveland Office, located at 1414 Victoria Avenue, Cleveland 7, Ohio.

HOT SALT PUMP

A new air-driven hot salt pump makes old-fashioned bailing methods unnecessary according to the Ajax Electric Co., Philadelphia, Pa. Designed especially for pumping molten salts and hot metals, the pump is powered by an air-driven motor which by its very nature is self-cooling. The pump body is made of a limited number of sturdy parts designed for operation under high ambient temperatures. Available in steel or with



stainless steel submerged parts (for temperatures over 1000°F.), the pump has a maximum flow capacity of about 36,000 pounds an hour using 90 psi air pressure. The volume can be reduced as desired by means of an air intake valve. Complete information is available in a new bulletin just published.

For further information circle No. 22

"SURE IS A SCORCHER TODAY, ... EH?"

MANUFACTURERS' LITERATURE

(Continued from page 48)

ALUMINUM DIGEST

"Reynolds Aluminum Digest", a compact monthly publication covering all aluminum news, is being made available to the entire metalworking industry by Reynolds Metals Company.

The "Digest" is a 32-36 page monthly publication, standard 8½ x 11 inches in size, containing 50 to 60 reviews of articles relating to aluminum that have been published in the technical press the preceding 30-60 days. To obtain this material, approximately 300 different periodicals are examined regularly. From 20 to 30 illustrations are also included in each issue of the "Digest".

In addition it carries a news summary of related current events, statistics on the aluminum industry, and patent listings. The main body of the periodical is broken down into separate sections covering developments in production methods, fabricating methods, properties, characteristics and standards, as well as new products and markets.

For further information circle No. 23

SELECTION OF SPECIALTY STEELS

A new 32-page, illustrated guide to specialty steels is now available to all steel users. Issued by The Carpenter Steel Company, Reading, Pa., the booklet defines the distinctive characteristics of a broad range of special purpose steels in terms of end use. It briefly summarizes the company's specialty product line, covering tool and die steels; stainless steels; silicon and high nickel electrical alloys; special purpose alloy steels; valve, heat-resisting and super alloy steels, tubing and pipe in various analyses and fine wire specialties. Corollary information is also given on the quality control necessary in the manufacture of specialty steels.

For further information circle No. 24

METAL TREATING

EQUIPMENT and MATERIALS DIRECTORY

AGITATORS

J. P. DEVINE MANUFACTURING CO.
49th Street and A. V. R. R.
Pittsburgh 1, Pennsylvania

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INTERNATIONAL NICKEL CO., INC.
67 Wall Street
New York 5, New York

MISCO FABRICATORS, INC.
1999 Guoin Street
Detroit 7, Michigan

THE PRESSED STEEL COMPANY
Wilkes-Barre, Pennsylvania

ROLOCK INC.
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Fairfield, Connecticut

STANWOOD CORP.
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Chicago 39, Ill.

WIRETEX MFG. CO., INC.
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CLEANING EQUIPMENT

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Fairfield, Connecticut

WIRETEX MFG. CO., INC.
16 Mason Street
Bridgeport 5, Conn.

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FURNACES

AMERICAN GAS FURNACE CO.
808 Lafayette Street
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DENVER FIRE CLAY COMPANY
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Denver, Colorado

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12045 Woodbine Ave.
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ECLIPSE FUEL ENGINEERING CO.
1018 Buchanan Street
Rockford Illinois

HEVI DUTY ELECTRIC COMPANY
Milwaukee 1, Wisconsin

HOLCROFT AND COMPANY
6545 Epworth Boulevard
Detroit 10, Michigan

INDUSTRIAL HEATING EQUIPMENT CO.
3570 Fremont Place
Detroit 7, Michigan

LINDBERG ENGINEERING CO.
2466 W. Hubbard Street
Chicago 12, Illinois

PERENY EQUIPMENT CO.
893 Chambers Road
Columbus 12, Ohio

SARGEANT & WILBUR, INC.
185 Weeden Street
Pawtucket, Rhode Island

SURFACE COMBUSTION CORPORATION
HEAT TREAT DIVISION
Toledo, Ohio

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FURNACES (Salt Bath)

AJAX ELECTRIC CO.
940 Frankford Avenue
Philadelphia 23, Pa.

THE A. F. HOLDEN CO.
14341 Schaefer Highway
Detroit 27, Mich.

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GASES

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NITROGEN DIVISION
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New York 6, New York

ARMOUR AND COMPANY
AMMONIA DIVISION
1355 W. 31st Street
Chicago, Illinois

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Detroit 10, Michigan

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2466 W. Hubbard Street
Chicago 12, Illinois

SARGEANT & WILBUR, INC.
185 Weeden Street
Pawtucket, Rhode Island

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Toledo, Ohio

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HEATING ELEMENTS (Non-Metallic)

NORTON COMPANY
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NITRIDING

UNITED STATES STEEL CORP.
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METAL FINISHING

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QUENCHING OILS

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303 W. Lehigh Avenue
Philadelphia 33, Pennsylvania

PARK CHEMICAL COMPANY
8076 Military Avenue
Detroit 4, Michigan

SHELL OIL COMPANY
50 West 50th Street
New York 20, New York

SUN OIL COMPANY
Industrial Products Department
Philadelphia 3, Pa.

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REFRACTORIES

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2301 Blake Street
Denver, Colorado

NORTON COMPANY
Worcester 6, Mass.

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SALTS

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NITROGEN DIVISION
40 Rector Street
New York 6, New York

AMERICAN CYANAMID COMPANY
METAL CHEMICALS SECTION
30 Rockefeller Plaza
New York 20, New York

THE A. F. HOLDEN CO.
14341 Schaefer Highway
Detroit 27, Mich.

E. F. HOUGHTON & CO.
303 W. Lehigh Avenue
Philadelphia 33, Pennsylvania

PARK CHEMICAL COMPANY
8076 Military Avenue
Detroit 4, Michigan

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STRAIGHTENING EQUIPMENT

GENERAL MANUFACTURING COMPANY
6437 Farnsworth
Detroit 11, Michigan

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METAL & THERMIT CORP.
100 East 42nd Street
New York 17, New York

CLARK INSTRUMENT, INC.
10203 Ford Road
Dearborn, Michigan

★ ★ ★

TOOL STEELS

BETHLEHEM STEEL COMPANY
Bethlehem, Pennsylvania

THE CARPENTER STEEL COMPANY
Reading, Pennsylvania

CRUCIBLE STEEL COMPANY OF AMERICA
Pittsburgh, Pa.

INDEX TO ADVERTISERS AND THEIR ADVERTISING AGENCIES